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DIFFUSE SOIL CONTAMINATION

INVENTORY OF DATA SOURCES AND PROPOSED APPROACH

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In this report, all data sources on diffuse soil pollution in Flanders have been inventoried, and the extent and impact of the problem is described. Part 1 provides an overview of known sources of diffuse soil contamination. Measurement data and other data are also listed, which can support certain links between sources and pollution. In part 2, the impact of diffuse soil contamination for various sources and parameters is qualitatively evaluated. Based on this evaluation, any gaps and possible further actions are identified. Part 3 describes a proposal for the further approach to diffuse soil pollution via soil policy.

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ABBREVIATIONS

abbreviation	meaning
AMPA	Aminomethylphosphonic acid, a decomposition product of glyphosate
ANB	Nature and Forest Agency
As	Arsenic
BAM	2,6-dichlorbenzamide
BDE	brominated diphenyl ethers (flame retardants)
BFR	Brominated Flame retardants
BOD	biological oxygen demand
BPA	Bisphenol A
CO_2	carbon dioxide
COD	chemical oxygen demand
Cr	Chromium
Cu	Copper
DBDPE	Decabromodiphenylethaan
DDT	dichlorodiphenyltrichloroethane
DEPH	bis(2-ethylhexyl) phthalate
DOV	Databank Ondergrond Vlaanderen (Flanders Subsoil Database)
EC	Emerging contaminant
FAA	Federal Aviation Agency
FANC	Federal Agency for Nuclear Control
FAO	Food and Agriculture Organization
Fe	Iron
HBCD	Hexabromocyclododecane
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
Hg	Mercury
ILVO	Institute for Agricultural, Fisheries and Food Research
IMJV	Integral Annual Environmental Report
JRC	Joint Research Centre
MCPP	Mecoprop
MO	Mineral oil
NACE	Statistical Classification of Economic Activities in the European Community
Ni	Nickel
NMBS	National Railway Company of Belgium
NOx	Nitrogen oxides
OBO	exploratory soil survey
OCP or OCB	organochlorine pesticides
OFP	organophosphorus pesticides
ONP	organo nitrogen pesticides
OVAM	Public Waste Agency of Flanders

PAH	Polyaromatic hydrocarbons
PBB	polybrominated biphenyls
PBDE	polybrominated diphenyl ethers
PCB	polychlorinated biphenyl
PCDD	Polychlorinated dibenzodioxins
PCDF	Polychlorinated dibenzofurans
PFAS	perfluorinated alkylated substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
PFR	Phosphororganic Flame Retardant
POP	persistent organic pollutants
PPCP	Pharmaceutical and Personal Care Products
RIVM	National Institute for Public Health and the Environment
RWZI	Waste water treatment plant
SAPEA	Science Advice for Policy by European Academies
STATBEL	Statistics Belgium
TBBP-A	Tetrabromobisphenol A
TCP	1,2,3-trichloropropane
TDS	total dissolved solids
TEQ	Toxic equivalence factor
TV	Technical report within the framework of reuse of soil materials
US EPA	United States Environmental Protection Agency
VITO	Flemish Institute for Technological Research
VLAREM	Flemish regulations governing environmental permits
VMM	Flemish Environment Agency
ZM	Heavy metals
Zn	Zinc

INTRODUCTION AND OBJECTIVE

The Soil Remediation Decree has been in force since 1995, with the aim of managing and remediating soil contamination in Flanders. This includes all forms of contamination of soil, sediment and groundwater. However, the legal instruments elaborated in the regulations are primarily aimed at soil contamination that can be directly linked to a clearly identifiable and easily locatable source or risk activity. The legal instruments include an inventory of contaminated soils, the allocation of investigation and remediation obligations, etc. However, the Soil Remediation and Protection Decree is intended for all forms of soil contamination, including diffuse soil contamination.

By diffuse soil contamination we mean:

- soil contamination due to all kinds of, often small-scale, artisanal activities (including the dumping and incineration of waste), often from the (distant) past, and for which the source and cause data have usually been lost;
- soil contamination caused by dispersed sources, e.g. atmospheric deposition, emissions from traffic, agricultural practices (fertilizers and plant protection products), discharges, floods, etc.;
- soil contamination that covers large areas, is often difficult to demarcate and involves serious risks, e.g. heavy metal contamination in the Campine region, etc.

In practice, these different forms of diffuse soil contamination are sometimes indistinguishable. The contamination can be in the solid phase or in the groundwater.

Until now, as a result of the specific focus of the legal instruments from the Soil Decree diffuse soil contamination has been addressed in a limited way end on an ad hoc basis. Diffuse soil contamination on large areas and with serious risks was addressed, as well as diffuse soil contamination that interferes with contamination from a known source or risk activity. In order to arrive at a management and approach for all soil contamination in Flanders in the long term, OVAM wishes to elaborate policy actions aimed at tackling diffuse soil contamination. More specifically, that approach will focus on diffuse soil contamination that is currently not yet addressed, often because it cannot be directly attributed to a known source or risk activity.

An approach for diffuse soil contamination is desirable for several reasons:

- The spread of diffuse soil contamination is often cited as one of the causes of loss of soil biodiversity and loss of soil ecosystem services. There is a need for long-term protection of the soil and its functions.
- Health risks can arise in both the short and long term, e.g. when the soil is used for growing vegetables or keeping chickens. Diffuse soil contamination can affect the quality of agricultural land in such a way that a safe food supply will be made more difficult in the future. Drinking water supplies can also be affected in the long term by diffuse soil contamination.
- Often there is a lack of clarity about the authority to act, and the instruments of the Soil Remediation Decree prove insufficient: e.g. in soil surveys carried out under the Soil

Remediation Decree, norms are exceeded regularly for parameters for which this was not expected, and for which it is often not clear who is obliged to investigate and remediate it.
– By mapping diffuse soil contamination and including it in the Soil Information Register, the technical information and any associated user advice can be made available to users and owners of land via the soil certificate.

As a first step in developing policy actions, we want to make an inventory of all data sources concerning diffuse soil contamination in Flanders, in which the size and impact of the problem is also described. This then serves as the basis for formulating proposals for the further approach to diffuse contamination in Flanders.

Part 1 of the study provides an overview of known sources of diffuse soil contamination. Data and measurement data that can support certain links between sources and contamination are also listed. In part 2, the impact of diffuse soil contamination for various sources and parameters is assessed qualitatively. Based on this evaluation, any gaps and possible further actions can then be identified. In part 3, proposals are formulated for the further approach to diffuse soil contamination via the OVAM soil policy.

PART 1 – INVENTARISATION OF DATA

Part 1 of this report contains an inventory of all data sources concerning diffuse soil contamination in Flanders.

Part 1 consists of 3 sections:

- Section 1 examines which substance groups can be relevant in the context of diffuse soil contamination in Flanders and lists the sources that can give rise to the emission of the substance. This is summarized in a sources-substances matrix.
- Section 2 checks which measurement data are already available regarding the presence of these substances in the environment.
- In the third section, we examine what information is known about the identified sources of these substance groups. This involves looking at the geographic location of the sources as well as emissions data. We examine how this data is/can be made accessible, in which format databases are available, etc.

1 FACTORS/SOURCES AND POSSIBLE SUBSTANCES

The factors that determine the probability of diffuse soil contamination are listed for various substancess. This matrix of factors/sources and substances will then be used to search and inventory data sources and/or to define gaps in knowledge.

1.1 HEAVY METALS AND METALLOIDS

1.1.1 Natural sources

Heavy metals in the soil have various natural sources, such as volcanic eruptions (arsenic, Hg, Cr, Cu, Ni, Zn (1)), forest fires or the weathering of minerals and ores (e.g. arsenic in the weathering of sulphite-containing rocks) (1). Increased arsenic concentrations in groundwater can also be the result of enrichment by soils containing glauconite. The VMM (2) also mentions the release of boron during the gradual sweetening of salt groundwater.

Specifically for heavy metals in soil, background values (target values) were determined by the VITO (confidential study, no detailed data available).

Some deposits, also in Flanders, naturally contain high levels of heavy metals, which can lead to the concentration of heavy metals in groundwater also being above the general groundwater quality standard, as defined in the VLAREM. To accommodate this, the concept of background level was introduced. Background levels indicate the expected concentration for a given substance in a given body of groundwater. If the background level is above the general groundwater quality standard, concentrations above the general standard do not necessarily indicate a major human impact. For the following metals and groundwater bodies, the quality assessment is therefore based on these background levels (2):

- Arsenic in the coastal and polder deposits: in the groundwater bodies within KPS_0160, the background level is 60 µg per litre.
- Nickel in parts of the Maas system and the Central Kempic system: there is a background level of 60 µg per litre in MS_0200_GWL_1 (HCOV 0200 south of the fault zone) and of 50 µg per litre in CKS_0220_GWL_1 (northern part of the Central Kempic System, phreatic part above the clay-sand complex of the Kempen region).

Background levels for groundwater included in the VLAREM are derived from concentrations of heavy metals measured in 2006, namely by determining the 90th percentile of the measured concentrations in samples without noticeable human influence. (2) This differs from the concentration used in the VLAREBO as the background value (target value).

1.1.2 Transport infrastructure

Heavy metals are released during various activities related to transport (1).

- Motorways:
  - Run-off of rainwater from roads can move particles rich in heavy metals. These particles originate from the corrosion of metal vehicle parts, tires and road surfaces.
  - In a German study, the accumulation of lead, cadmium, zinc, copper, nickel and chromium along one of the oldest German highways was mapped. This showed that the concentrations of heavy metals along the road bed are up to 20 times higher compared to a reference surface 800 m from the road. The highest concentrations are usually found in the top 10 centimetres of the soil. (3)
  - A 2012 study along 2 major rural roads showed that metal deposition decreases rapidly with distance from the road. The concentrations measured in this study were below the background values from a distance of 25 m from the road. Zinc, lead and copper were the most significant metals present. The contamination seemed mainly concentrated in a 5 m band along the road. Galvanized guardrails also proved to be an additional source of zinc. (4)
  - In the Netherlands, a calculation method was developed on behalf of the Directorate-General for Public Works and Water Management to calculate the emissions of particulate matter, coarse dust, metals, PAH and nonylphenols as a result of tire wear (5). The emissions of zinc to the soil as a result of tire wear are particularly significant (see also Section 3.2.4).
  - Lead contamination from leaded petrol is a significant historical source. The FAO reports that approximately 10 million tons of lead worldwide has been released through this source, of which 5.9 million tons are in the United States. Soil contamination related to this is concentrated around roads, especially in urban environments. (1)
  - In 2016, traffic was the largest source of copper emissions and the second largest source of lead, zinc and chromium into the air (6) in Flanders, mainly due to the wear of the brakes, which releases metal particles. In view of the density of the road network in Flanders, copper must have ended up in the soil almost everywhere. The agricultural use of copper, together with the deposition of emissions from transport, causes a diffuse load on the soil that cannot be reduced to specific regions, but which manifests itself virtually throughout Flanders (6).

- **Shipping** was also a significant source of arsenic and nickel (6). In a study into the emissions of sea-going vessels in Belgian waters (7), an estimate was made of the atmospheric deposition of PAH and the metals cadmium and lead as a result of the emissions from sea-going vessels. The proportion of ship emissions in the deposition of cadmium and lead turned out to be rather limited.

- Metals are also released **along railways.** Lead, copper and zinc are considered the most important inorganic contaminants here. Studies have shown that train traffic increases the amount of copper in nearby soil by up to 20 times. In the locations studied, the copper concentration was usually higher in the surface layers; concentrations were measured to 565 mg/kg dw, the concentration decreasing with depth. The wearing of wheels, tracks and power supply can cause metals to be released in aerosols and thus contaminate the wider environment of the railways. Washing facilities and railway sidings are also contaminating source zones; concentrations of Pb, Cu, Zn, Fe, Cr and Hg may be several times higher than relatively clean control areas. (8)

- **Aviation** releases lead into the environment through its presence in kerosene. This mainly concerns historical contamination, but today tetra-ethyl lead is still used in kerosene (Avgas) for small aircraft with propeller engines, because a safe alternative has not yet been found. The FAA estimated the number of such aircraft at 167,000 in the United States and 230,000 in the world in 2013 (9). Atmospheric deposition can contaminate the soil, especially near airports. A study carried out in the United States found that children who live within 500 m of an airport with aircraft using Avgas have higher blood lead levels. The effect could also be measured at a distance of 1000 m from the airports. (10)

- Antwerp port area: Embankments in the port area during the construction of the port (on top of polder clay) also result in increased regional levels of heavy metals.

1.1.3 Construction materials

The VMM estimates the emissions of heavy metals to the surface water every year (see Section 3.2.2.2). According to the most recent report (11), the main sources of most heavy metals in surface water are soil erosion and atmospheric deposition. However, infrastructure is the largest source of zinc. 94% of zinc emissions from infrastructure are said to come from building shells (including guttering) and 6% from corrosion by water pipes.

Lead enters the environment when paint containing lead is pulverized into small particles, such as during renovation or demolition. In the United States, roughly the same amount of lead was used in paints between 1884 and 1989 as in gasoline in the period between 1929 and 1989. The peak of consumption fell here in the period 1920-1929. An inventory study of risk locations for diffuse lead in North Holland (12) also mentions that in the past manure was used in the production of white lead. Lead bars were placed in pots. The pots were then placed in manure and covered with manure so that it started to heat. The manure was spread over agricultural land after the process. This is a known cause of diffuse lead contamination around Rotterdam, Amsterdam and Zaanstad.

The VMM and Vito developed a calculation method to estimate the diffuse emission of heavy metals to water as a result of corrosion of building materials (13). 14 metals have been identified that can occur in water drained from buildings: copper, zinc, lead, aluminium, iron, silver, titanium, magnesium, tin, bismuth, antimony, sodium, nickel and chromium. If this water drains into the soil, this can also lead to diffuse soil contamination.

A Dutch study (14) shows that around synthetic turf fields, which contain rubber granulate from recycled tires, increased concentrations of zinc, cobalt and mineral oil can be found from leaching from the granulate. These substances also enter the surface water and the sediment via the drainage water from such fields.

1.1.4 Energy and Waste

Based on the VMM's estimates of heavy metal to air emissions, waste incineration is a significant source of heavy metals. For arsenic and cobalt, the share of the energy and waste sector in the total emissions of these metals is significant. (6) (2).

In addition, an inventory of sources of local soil contamination drawn up by the RIVM in 1994 (15) also mentions high-voltage pylons as a source of zinc. These pylons are galvanized and, due to corrosion and run-off, part of the zinc applied ends up in the environment. Measurements showed that elevated concentrations of zinc in the soil were observed up to 20 to 25 m around the pylon. This results in a loaded area of 1250 to 2000 m³ per pylon.

Lokatie	bodemgehalte (mg/kg d.s.)	diepte (cm)	aantal jaar na bouw	bron
Nederland	200-650	0-20	6	Lexmond, 1987
Canada (op eiland)	200-550	?	25	Balch en Jones,1991
Noord-Wales	1250-6500	?	27	Al-Hiyaly, 1988
Canada	8400-17400	0-5	30	Jones, 1983

Figure 1-1: zinc content in soil near high-voltage pylons (naar Meij 1992 - (15)) xxx

This study also mentions that more recent pylons are painted approximately 1 year after construction, which greatly reduces zinc emissions.

A recent study also examined whether heavy metals and metalloids can leach from solar panels (16). They analysed soil samples near the installation of solar panels. They did not detect increased concentrations of lead or cadmium, but they did detect selenium, lithium, nickel, barium and strontium.

1.1.5 Metal processing industry

Since the mid-19th century, there has been metal refining in the Kempen region, mainly from concentrates containing zinc. This has led to atmospheric emissions of metals. In addition to emissions into the air, the zinc ash from the factories - which also contain cadmium, arsenic, copper and lead - were also used in the construction of roads in (mainly) the provinces of Antwerp and Limburg (2). To this day, this results in high concentrations of a whole range of heavy metals, especially cadmium, arsenic, lead, zinc, nickel and cobalt.

Researchers calculated that within a radius of 2 km around the zinc factories of Overpelt, Balen and Lommel, more than 3 grams of cadmium per m² was deposited in the period 1890-1973. Furthermore, the deposition is clearly lower: 0.4 to 0.8 g/m². The deposition reaches furthest to the north-east of the sites because (south-) west winds are most common in Belgium. (2)

The VMM estimates the emissions of heavy metals into the air annually (see Section 3.2.2.1). Based on the most recent report (6), the metal industry still has the largest share in the emissions of lead, cadmium, chromium and manganese. Zinc emissions fell sharply between 2000 and 2016.

Soil
In 2008, a study was carried out on behalf of OVAM into the effect of these diffuse enrichments on earthmoving in the Noorderkempen region (17).

Based on this, zones were defined for Cd, Zn, Pb and As where concentrations above the values for free reuse were found. This resulted in an estimate of 54 million m³ of land within the 9 km zones. Cd often proved to be the determining parameter.

Groundwater
The VMM (2) reported a human influence on the concentrations of multiple heavy metals in the groundwater near metal processing factories in the east of the province of Antwerp and in the northern half of Limburg.

- Cadmium and cobalt
  There are no known natural sources of cadmium in Flanders, so the abundance of cadmium in the groundwater in the Kempen region is almost certainly due to human activitie. Cobalt does occur naturally, but the concentrations found are too high to be completely natural (2). The predominantly eastern distribution direction of the particle cloud is also noticeable in the cadmium concentration of the groundwater. The VMM (11) reports that the influent concentrations of cadmium in WWTPs in the north of Limburg are higher than the rest of Flanders and that this is the result of the infiltration of contaminated groundwater into the sewer system. The same finding is made for nickel and zinc, but slightly less pronounced.

  The impact of these zinc ash routes on groundwater quality can be estimated by examining the relationship between the cadmium concentration and the distance to the nearest zinc ash route. There is a negative relationship between those two variables, which suggests that zinc ash routes influence the cadmium concentration of groundwater. A correlation was also found for zinc, cobalt and nickel.

- Lead
  The high lead concentrations in groundwater in northwest Limburg and the adjacent municipalities in the province of Antwerp are most likely partly due to the metalworking industry in the region (2). The FAO also states that companies that recycle lead batteries can be considered major sources of lead contamination worldwide (1).

- Nickel

For nickel, too, the large number of standard exceedances in groundwater in the Kempen region can be linked to emissions into the air by the metal industry in that region and to the use of zinc ash in the construction of roads in the wider area.

1.1.6 Other industries

There are various other industrial sources of metals apart from the metal industry, the chemical industry being the most important.

A known historical problem is soil contamination with mercury as a result of haircutting (for hats and felt) in the vicinity of Lokeren. These activities have been carried out in this area since the 18th century. A mercury preparation was used to make felt. The mercury solution then was discharged into ditches and sewers (18).

Arsenic and chromium were also often used in the woodworking industry as a biocide to protect wood. (19)

Mining and mining waste is (generally) cited as a source of diffuse heavy metal contamination. The mining waste consists of fine particles containing heavy metals. The particles are then dispersed by wind and water erosion (1). In Flanders, mining waste originatesfrom the former coal mines.

1.1.7 Ammunition

In addition to industrial point emissions, heavy metals may also have been released into the environment from military activities. For example, mainly copper, lead and zinc are considered to be 'war metals' due to their presence in ammunition and arsenic is a metal found in some poison gases. In 2009, a report wasy compiled by the OVAM on the regional increase in some heavy metals in the Ypres region as a result of the First World War. This showed that copper in particular showed a broad regional pattern since this element can be associated with many military activities. Lead, on the other hand, concentrates in a closer band around the front zone, which is probably linked to the use of grenades containing lead. (2) (20)

Increased concentrations of lead, antimony, arsenic copper, nickel and zinc are also measured in the soils around shooting ranges and military areas. Worldwide, lead concentrations above 10,000 mg/kg dw are measured at shooting ranges. (21).
The annual lead exemption for hunting is estimated at 500 tons in Switzerland, 800 tons in Denmark and 60,000 tons in the United States. (21)

1.1.8 Agriculture and livestock farming

Traces of metals in agrochemicals such as boron, copper, cadmium, lead and mercury can lead to soil contamination (1). Fertilizers can also be a source of heavy metals such as zinc, mercury, cadmium, arsenic, lead, copper and nickel (1).

If an excess of nitrate leaches into the groundwater through fertilization, it can oxidise metal sulphides there, whereby nickel is released (2). In addition, most animal fertilizers contain a limited amount of nickel (2) and pig manure, in particular, can provide the soil with zinc and copper (2). More than 80% of the contribution of heavy metals from manure to the soil load consists of zinc and copper (22).

Tabel 3.2 Overzicht van de mediane gehalten aan Cd, Cu, Cr, Ni, Hg, Pb, Zn en As in varkens- runder- en kuikenmest in mg kg^{1}ds (1996: Driessen en Roos, 1996; 2008: dit onderzoek). Daarbij is geen onderscheid naar regio's gemaakt. Opvallende verschillen zijn grijs, of vetgedrukt.

Metaal	Mestsoort					
	Vleesvarken		Rund		Vleeskuiken	
	1996	2008	1996	2008	1996	2008
Cd	0.30-0.62	0.35	0.19-0.24	0.25	0.18-0.19	<0.21
Cr	14-19	8.1	6.2-8.4	<6.4	5.7-8.1	3.9
Cu	397	404	42	**135**	138	**78**
Hg	0.03-0.04	<0.14	0.03-0.05	<0.12	<0.02-0.03	<0.04
Ni	21-24	9.2	10-17	4.5	8.4-16	3.3
Pb	14-22	<5.6	8.0-18.0	<4.8	10-18	<6.3
Zn	564	**952**	156	**198**	307-386	**266**
As	0.6-0.9	1.85	0.3-0.5	1.6	0.4-0.6	< 1.1

[1] voor Driessen en Roos (1996) is dit de range voor de verschillende mestsoorten per dier, waarbij wel dezelfde diercategorie is gehandhaafd. Fokvarkens zijn bijvoorbeeld niet meegenomen.

Figure 1-2 Source (22)

In the 20th century, lead arsenate was used as a pesticide in fruit crops and as a wood treatment

agent to prevent rotting (chromium copper arsenate, CCA) (23). In addition, fungicides based on copper were also used (e.g. copper sulphate). (23)

The analysis results for copper from the LUCAS soil survey (see Section 2.2.1.6) were studied in a 2018 study (24). This shows that the average copper concentration in the top layer of soils in Europe is 16.85 mg/kg. In vineyards, however, the average concentration is 49.26 mg/kg, which is the highest concentration in all the land use categories studied. The vineyards were followed by olive groves (33.5 mg/kg) and other orchards (27.3 mg/kg). The study also found that in addition to using copper as a fungicide, the combined effect of soil properties such as high pH, organic carbon, clay content and a humid climate play a role in copper accumulation in vineyards and orchards. (24)

The VMM (2) also reports that several studies in the United States show that the past use of arsenic-containing pesticides in agriculture has no significant impact on arsenic concentrations that occur in shallow groundwater today. In Flanders, too, there is no direct link between arsenic in groundwater and agricultural activities. This could be explained by the physico-chemical conditions in the soil, but it also indicates that the possible use of arsenic-containing pesticides cannot be a decisive explanation for the arsenic content of the groundwater in Flanders. (2)

1.1.9 Coal ash

Coal ash from coal burning in stoves contains heavy metals, PCDD/F and PAHs. These ashes were often used in gardens in the past. Even now, the use of ash from (wood) stoves is recommended as a fertilizer on various gardening forums. Given the widespread use of coal stoves in Flanders in the past, it is likely that in many places these ashes have ended up in the soil and thus form a source of diffuse soil contamination.

1.2 POLYAROMATIC HYDROCARBONS

1.2.1 General

Polyaromatic hydrocarbons (PAHs) are an important class of organic contaminants because of their widespread appearance and their potentially toxic effects on ecosystems and humans. (25) Total global atmospheric emissions of PAH16 in 2004 were estimated at 520 gigagrams per year (Gg/y). (26)

Soil contains measurable amounts of PAHs, mainly from precipitation from the air. In the vicinity of oil refineries worldwide, concentrations of PAHs in the soil have been recorded of up to 200 mg/kg dry weight. Concentrations in soil samples taken near high traffic cities are typically less than 2 mg/kg. (26) (27)

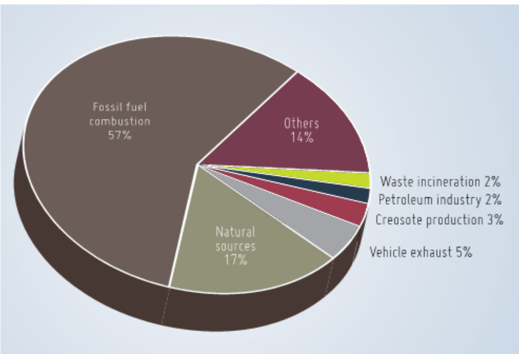


Figure1-3 Sources of PAHs in urban areas: (1)

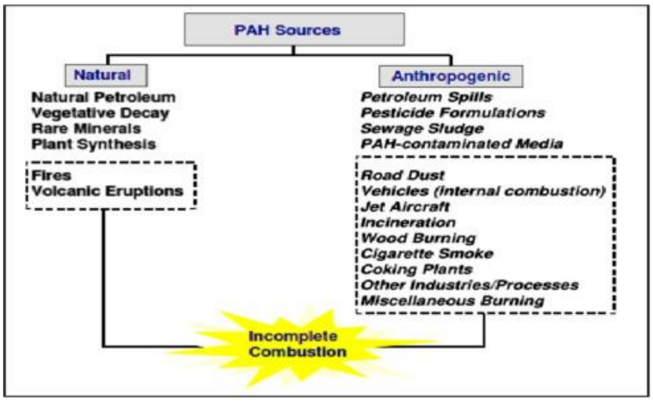


Figure1-4: sources of PAH (1)

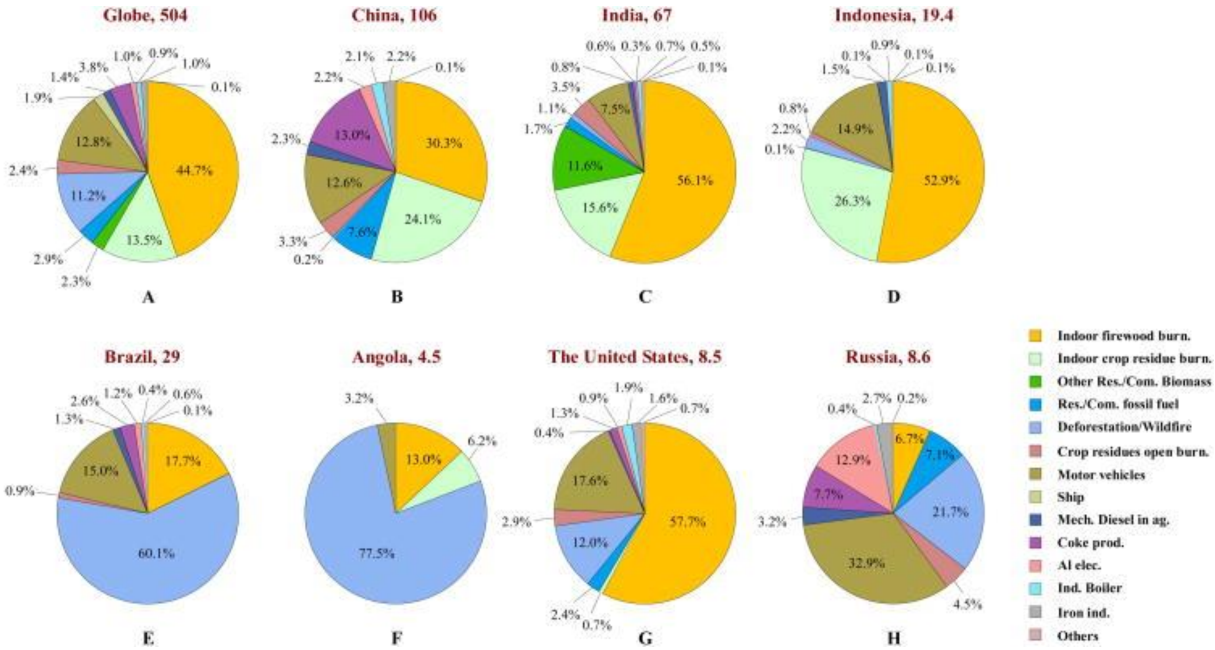


Figure1-5: Sources of PAH emissions around the world. (25)

1.2.2 Natural presence

The FAO (1) lists volcanic eruptions, space dust and meteorites as natural sources of PAH, and biogenic production of PAHs in reducing conditions. PAHs can be synthesized by some plants and bacteria, or arise from the decomposition of plant material. In addition, PAHs are a natural component of raw fossil materials such as coal and petroleum. The latter contains between 0.2% and 7% PAHs (28). Wildfires are also a source of PAHs.

1.2.3 Combustion processes

PAHs are formed during the incomplete combustion of organic material. As sources of PAHs, the FAO cites the incomplete combustion of coal, gas, oil and waste. As well as pyrolysis of organic materials by industry, agriculture and traffic (1). Traffic emissions and fossil fuel combustion are the main anthropogenic sources of PAHs (1).

1.2.3.1 Households

In Flanders, households are responsible for the vast majority of PAH emissions (a share of more than 88% in 2012). This share is still rising on the basis of the most recent figures, although this is mainly due to declines in the other sectors (6). The main household source is building heating (responsible for 98% of the household PAH emissions) and mainly the combustion of wood in stoves and fireplaces. The remaining household PAH emissions come from the burning of waste in barrels and open fires, including barbecues.

Emission factors of PAHs from wood burning range from 16.4 to 1,282 mg/kg of wood. The concentration of PAHs released in this process depends on the type of wood, type of oven and combustion temperature. (26)

Coal ash from coal burning in stoves contains heavy metals, PCDD/F and PAHs. These ashes were often used in gardens in the past. Even now, the use of ash from (wood) stoves is recommended as a fertilizer on various gardening forums. Given the widespread use of coal stoves in Flanders in the past, it is likely that in many places these ashes have ended up in the soil and thus form a source of diffuse soil contamination.

1.2.3.2 Industry

PAHs from industry are produced by burning fuels such as gas, oil and coal. PAHs can also be emitted during the processing of raw materials such as aluminium ores. Additional sources of PAH are emissions from industrial activities such as the production of coke, petrochemicals, rubber, and the production of cement, bitumen and asphalt. In the past, city gas factories were major sources of soil contamination with PAH. Commercial heat and energy production and waste incineration are other sources. (26)

According to the Italian Agency for Environmental protection, the emission factors of PAHs from waste incinerators range between 91 and 414 µg/g incinerated waste (26).

1.2.3.3 Traffic and transportation

PAHs are mainly emitted from vehicle exhausts, including cars, trains, ships, aircraft and other motor vehicles. PAH emissions from mobile sources are related to the use of diesel, coal, oil and lubricating oil. (26)

In a study conducted around New Delhi International Airport in India, increased concentrations of PAHs were found in soil, with a maximum concentration in the vicinity of the runway. (29).

Diesel locomotives use a combustion engine and, like road traffic, they release polycyclic aromatic hydrocarbons. (8)

In a study into the emissions of sea-going vessels in Belgian waters (7), an estimate was made of the atmospheric deposition of PAH and metals as a result of the emissions from sea-going vessels. Above the busiest shipping routes in the North Sea, the contribution of PAHs as a result of ship emissions is 13-34% of the total PAHs in atmospheric deposition. Above Flanders, the share of PAH from sea-going vessels in the total deposition is approximately 0.2-1%. From this it can be expected that on the busiest inland waterway routes the contribution of PAHs as a result of the ships is also significant.

1.2.3.4 Agriculture and livestock farming

Burning undergrowth, straw, heather and plant debris are agricultural sources of PAHs. Since all these activities involve the combustion of organic matter under sub-optimal conditions, significant amounts of PAHs can be expected to be released. (26)

1.2.4 Construction materials

1.2.4.1 Materials for road construction and roofing

Refining processes such as coal coking and petroleum cracking produce products such as coke, fuels, wax and oil. The ashes produced in these processes are incinerated or can be used as building materials in roads. If PAHs are not removed from these ashes before they are used as construction material, they will end up in the environment. Pitch and tar are also used as binders in surfaces made of asphalt, paving and roofing. (28)

1.2.4.2 Protective coatings and adhesives

Pitch that arises as a waste product in the processing of coal, and therefore contains a large amount of PAHs, is often used in paints and coatings. These coatings protect against corrosion, so they are often used on steel structures of hydraulic infrastructure, ships, harbours and pipelines to protect them from rust. (28)

Since PAHs are toxic to organisms such as fungi, they are also used in wood preservation. Creosote, which comes from coal tar, is often used for this. Creosote can still be used for the treatment of railway sleepers (see also Section 1.2.6), telephone and electricity poles and for fencing of agricultural land. (28) These creosote-rich railway ties are often also used to close off pastures, to reinforce streams or in gardens. There they can also result in diffuse soil contamination.

1.2.4.3 Minestone

Minestone is a collective name for the rock that is released as a residual product during the extraction of coal. Often this minestone has ended up on above ground dumping sites or spoil tips. Subject to the final and binding destinations of the remodulated mining spoil tips, a virtual reserve of approximately 90,000 kton of minestone is available in the former mining area of Central Limburg. The analyses carried out on rock dumping material from Limburg spoil tips show that they have a high to very high salt content (up to several thousand ppm). This high salt content can partly be traced back to the high pyrite contents in the starting material. The salts in the spoil tip material mainly consist of the relatively sparingly soluble $CaSO_4$ and the more soluble $MgSO_4$. This can cause problems related to sulphate leaching. Other possible contaminants are phenols, PCBs and PAHs. The latter come from residues of mine wood, machine parts and machine oil. (30)

Mine stone can be used as a building material, subject to a raw material declaration (30).

1.2.5 Rubber and plastics

Tar oils and specific oil from petroleum refining are used as plasticizers in rubber and plastics. The largest proportion of PAHs that reach the consumer does this through this pathway (28). Independent laboratories continue to find elevated PAH concentrations in consumer goods, including tool and bicycle handles, shoes and sports equipment. These are mainly cheap and imported products containing oils with PAHs. (28)

1.2.5.1 Tyres

Until 2009, PAH-containing oils were allowed to be used in car tyres. Since 2010, a European limit has been set for the use of PAH-containing oils in car tyres. In addition to PAHs from tyre wear, the release of PAHs from scrap tyres and the combustion of tyres also causes emissions of PAHs (26).

1.2.5.2 Products made from recycled tyres (28)

The introduction of strict limits for PAH-containing oils in tyres solved the problem of PAH release from tyre wear. However, up to 20% of the tyres are recycled. Tyre recycling is recommended, but it also ensures that materials produced before 2010 and thus still containing a high concentration of PAHs remain in circulation. Used tyres are also used, for example, in the production of floors in which the recycled granulates are mixed with the new individual ingredients. (28) Leaching PAHs from material made from recycled tyre rubber (e.g. shock absorbing tiles in playgrounds) ensure that tyres are a source of PAHs throughout their entire life.

Sports fields have been made from recycled aggregates for several years. A commonly used design are synthetic turf fields that are filled with recycled rubber granulates. In the construction industry, recycled tyres are used as a protective layer, to protect waterproof layers or to cover tunnels. (28)

1.2.6 Roads and transport infrastructure

As shown in the sections above, run off from roads may contain PAHs due to tyre wear. But PAHs are also a major contaminating parameter in the vicinity of railways. For example, during a study in Poland, significantly higher concentrations of PAHs were found in the soil of the railway bed; the concentrations of PAHs found were up to approximately 155 times higher than the concentrations measured at control sites. (9) The emissions from diesel locomotives play a role, but the wooden sleepers of the tracks are also a source of PAHs. These have often been treated with creosote. Rail sleepers release about 1/3rd of their total creosote content over their average 26-year lifetime, which is released into the environment. (28)

A study from Switzerland (31) estimated that each sleeper releases 5 kg of creosote over its lifetime of about 20-30 years. The annual total PAH emissions from sleepers in Switzerland would be about 139 tons, that of phenols about 4 tons.

1.2.7 Agriculture and livestock farming

Irrigation with wastewater, reuse of sewage sludge and fertilizers in agriculture can result in high concentrations of PAHs in agricultural soils (1).

In addition, considerable amounts of fuel are also used in greenhouse horticulture for heating the greenhouses and fertilizing with CO_2. However, the VMM mainly mentions NOx and sulphur emissions in this context. Moreover, there is a noticeable decrease here over the period from 2000 to 2016 due to the switch from fuel oil to natural gas and renewable fuels (biogas) (6).

1.3 MINERAL OIL

1.3.1 Transport

Within the context of diffuse soil contamination with mineral oil, runoff from roads is mainly cited as a source. Some studies indicate the main source of this is crankcase oil, which is used in the internal combustion engine.

Another possible source of diffuse mineral oil soil contamination around airports is the dumping of fuel by aircraft. Aircraft have a maximum allowed weight for take-off on the one hand and on the other hand a design weight for landing. In aircraft types where no provision is made for landing with extra weight on top of the design weight, a system for discharging fuel may be necessary. If such an aircraft has to return shortly after take-off or make an emergency landing, not enough fuel will have been used yet to reach the landing weight. Then some of the fuel must be discharged in order to be able to make a safe landing. This is referred to as “fuel dumping” or “fuel jettison”.

Many modern aircraft can land with an excess of weight and are therefore not equipped with these jettison systems. If it is necessary, it is preferable to discharge the fuel at a height of more than 5000 m in order to dilute the fuel before it reaches the ground and under the supervision of air traffic control. A Boeing 747 can discharge up to 1 to 2 tons of fuel per minute.

1.3.2 Agrochemicals

Mineral oil is also used in agricultural pesticide formulations. Spray oils are administered as an adjuvant to improve the spread, wetting and persistence of plant protection products.

1.4 PESTICIDES

1.4.1 General

The term pesticide is a collective name for plant protection products and biocides. Plant protection products protect crops against harmful organisms or control weeds. They are mainly used in agriculture, but also in gardens. Biocides also fight harmful organisms, but they are not strictly related to agriculture. Examples are disinfectants, mouse poison, wood preservatives and repellents.

There are very many different types of pesticides. Given the large number of pesticides, it may be interesting to initially look at the pesticides included in the POP convention.

The VMM (32) conducted a study into the prevention of pesticides in groundwater in Flanders. It concluded that shallow parts of the groundwater system are on average more contaminated with pesticides than deep parts. They also report that little quantitative data is available on the use of pesticides (in Flanders). The study therefore attempted to find out the possible origin of pesticides on the basis of land use information, whereby the municipal boundaries were chosen to define the land use in a zone (see also Section 3.2.8).

Based on the VMM report (32), herbicides are particularly relevant in the context of groundwater contamination. Insecticides and fungicides target insects and fungi, respectively, and are therefore both applied to the crop. The fraction that ends up in the soil and can infiltrate is small if these pesticides are used correctly. Farmers and individuals, companies and governments all use pesticides. Herbicides are deliberately applied on the soil (32).

Pesticides are widespread in Flanders. In 56% of the groundwater samples that the VMM had analysed in 2010, some pesticide or decomposition product was found in concentrations above the legal quality standard (0.1 µg/l) for drinking water. Pesticides (or decomposition products of) are found in half of all drinking water extractions studied in 2009. This large-scale analysis clearly shows that the cause of the pesticide problem lies both in agricultural use and in non-agricultural use (on pavements, in gardens, on roadsides, in green zones, etc.) of pesticides. This was evident, for example, from the spatial variation in the concentration of BAM and diuron: in some residential zones - where we find little agricultural activity - high concentrations of these substances occur. (32)

1.4.2 Arable farming

According to the JRC report “soil threats in Europe” of 2016 (33), more than 3000 different types of pesticides have been used in agriculture in Europe in the last 50 years. The figure below shows that consumption per area of agricultural land was highest in Belgium.

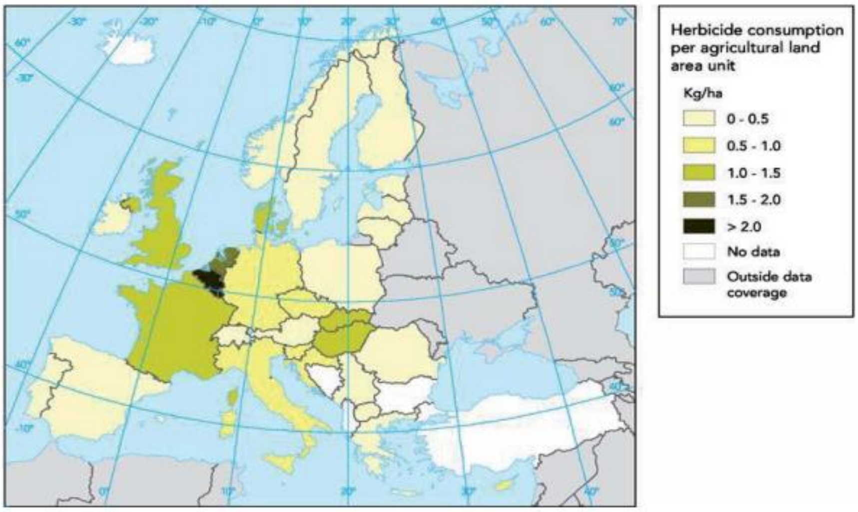


Figure1-6: herbicide usage in the EU countries (33)

It is estimated that less than 0.1% of the pesticides applied to the crops also effectively reach the intended receptor. The remainder ends up in the environment and contaminates the soil, water and air where they have a negative effect on organisms. Many of these pesticides are also very persistent. Few studies are available that monitor the mixture of pesticides in European soils. The European Commission does have data on pesticide use per country, but there is little data on the current pesticide concentration in European soils. (23)

A few studies were conducted in 2017 and 2018:

- the JRC and the University of Wageningen conducted a study on the occurrence of various pesticides and decomposition products including glyphosate and AMPA in European soils (34) (35). 317 top samples were analysed from 11 European countries: the United Kingdom, Denmark, Italy, Greece, Spain, Hungary , Poland, the Netherlands, France and Germany. The other 17 samples came from Portugal (no samples from Belgium); the samples were spread over 6 different crops. (34) (35). 76 different substances were analysed, 43 substances were detected. Given that less than 20% of the currently approved active substances in the EU were analysed, the actual number of substances in the soil canbe expected to be higher. Pesticides were found in 83% of the samples analysed. More than 1 pesticide was found in 58% of the samples in more than 166 different combinations. Substances that were found most frequently and at the highest concentrations were glyphosate, AMPA, DDT and decomposition products and the fungicides boscalid, epoxiconazole and tebucanazole. The toxic effects of mixtures of pesticides on soil life is unknown. The maximum total pesticide concentration was 2.87 mg/kg. Glyphosate and AMPA contributed most to the total concentration. Maximum concentrations up to 2 mg/kg AMPA and glyphosate were measured.

Glyphosate was found in 21% of the samples. The decomposition product AMPA was measured in 42% of the samples. The highest concentrations were measured in the southern soils, however, a higher frequency of occurrence was found in the northern soils.

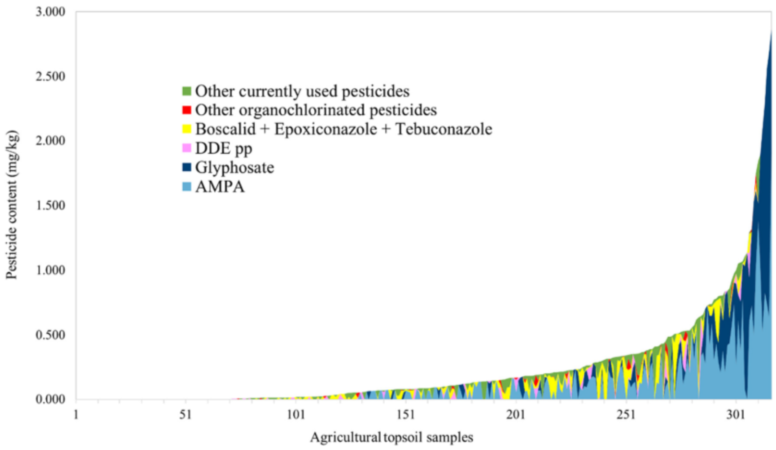


Figure 1-7: Pesticide distribution across the 317 EU agricultural topsoil samples. Topsoil samples (numbered from 1 to 317) were organized by increasing total pesticide content. (34) (35)

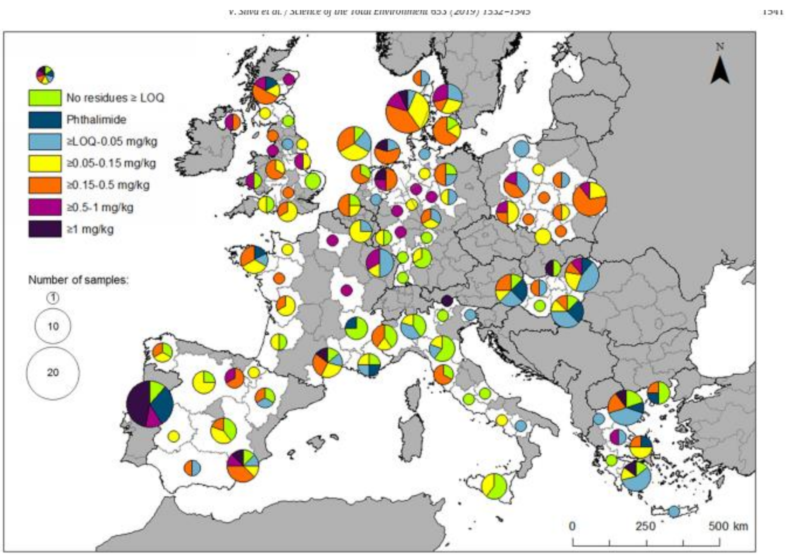


Figure 1-8: distribution of total pesticide contents in EU Agricultural topsoils (0-15/20 cm)at the NUTS 2 level. The pie-charts represent the proportion of soil samples from each NUTS 2 region. The size of the pie-charts represents the sampling effort by NUTS 2 regions, with bigger circles corresponding to a higher number of soil samples. The white and grey areas in the map represent sampled and not-sampled NUTS2 regions. (34) (35)

- In another study, 75 soil samples from agricultural land spread across the Czech Republic were analysed for 53 pesticides and 15 decomposition products. The most commonly encountered substances were triazines and conazoles, even though triazines (simazine and atrazine) have been banned for several years. A relationship between decomposition products of simazine and the use of terbuthylazine has been found to indicate that terbuthalazine may contain simazine as an impurity. More than 50% of the samples contained residues of 5 or more pesticides. 36% of the soils contained 3 or more pesticides with concentrations > 0.01 mg/kg. (36).

1.4.3 Fumigation

Some products are applied in gaseous form (fumigation), these substances are mainly used to combat nematodes. Several such pesticides contain an impurity of 1,2,3-trichloropropane (TCP), a substance used in the manufacturing process. This substance has led to the creation of groundwater contamination in the United States. TCP adheres poorly to the soil and therefore tends to leach into the groundwater. Since it is heavier than water, it forms hard-to-clean sink layers (EPA, fact sheet).

The substance was already found in groundwater in the Netherlands too, within a concentration range of < 0.05 µg/l to 9.1 µg/l in 52 groundwater samples from the region around Drenthe (TOXNET).

The products themselves that are used for fumigation are very toxic with very low LD 50 values. They can also have effects on soil and groundwater. Most of these substances were developed 50 to 60 years ago. Only relatively recently, potential dangers became apparent and their use was regulated or prohibited. Most nematicides biodegrade in the top layers of the soil. However, if they wash out to deeper soil layers, they are more persistent and can affect the groundwater. In some European regions with intensive agriculture, the drinking water standard of 0.1 µg/l of pesticides is exceeded during certain times of the year. (37)

Table 1-1 Nematicides available on the world market (38)

Chemical name	Trade name	Formulation
Fumigants		
Methyl bromide	Dowfume	Gas
1,3 dichloropropene	Telone/DD-95	liquid
Ethylene dibromide1	Dowfume W-85	liquid
Metam-sodium	Vapam	liquid
Dazomet	Basamid	solid
Methyl isothiocyanate	Di-Trapex	liquid
Chloropicrin[1]	Larvacide	liquid
Organophosphates		
Thionazin	Nemafos	Granular or emulsion
Ethoprophos	Mocap	Granular or emulsion
Fenamiphos	Nemacur	Granular or emulsion
Fensulfothion	Dasanit	Granular
Terbufos	Counter	Granular
Isazofos	Miral	Granular or emulsion
Ebufos	Rugby	Granular or emulsion
Carbamates		
Aldicarb	Temik	Granular
Aldoxycarb	Standak	liquid

Oxamyl	Vydate	Granular or emulsion
Carbofuran	Furadan/Curaterr	Granular or liquid
Cleothocarb	Lance	Granular

[1] Use restricted.

Some of the substances used as nematicides are chlorinated components: 1,3-dichlororopropene and 1,2-dichloropropane, or “DD,”; These are by-products of the petrochemical industry and therefore very cheap. These were widely used in California (37). In Flanders, products containing 1,2 dichloropropene were also permitted until 2016 (Fytoweb: The agent TELONE II is authorized for use against soil insects and nematodes from 20/05/2016 for a period of 120 days).

1.4.4 Fruit cultivation

In the period 2015-2016, the VMM carried out analyses of 57 pesticides in influents and effluents from 8 WWTPs in Haspengouw. Haspengouw is known as the fruit region of Flanders. Among other things, apples, pears, cherries, strawberries, raspberries and grapes are grown. The number of pesticides found in these WWTP effluents is almost always higher than in the rest of Flanders (39).

1.4.5 Private use and public services

For several years, public services in Flanders have reported their pesticide use annually to the VMM. Since 2015, there has been a principle ban on the use of pesticides by public services, which can only be deviated from in certain cases. As a result, the use of pesticides outside agriculture shows a decrease in 2015.

The report “sustainable use of pesticides” provides an overview of the pesticide use of public authorities (40). In general, it can be stated that the pesticide consumption of public services decreased from 15.7 tons of active substances to 4.1 tons of active substances between 2010 and 2017.

Since 2015, derogations must be requested for the use of pesticides. Most of the derogations were requested for the control of rats, wasps, oak processionary caterpillars and boxwood moths or for keeping cemeteries weed-free.

If these derogations are not taken into account, it can be concluded that the vast majority of the pesticide use of the municipalities is situated in green maintenance.

The following uses relevant to this study were reported to the Flemish authorities:

- Ballast beds of public transport trams (mainly Ghent, Antwerp and the coast)
- Control of invasion plants by ANB
- Fighting alien species along regional roads
- Weed control along railway lines:
    - Infrabel: railway bed and adjacent safety path (using a “spray train” along the main lines), signal boxes
    - NMBS: platforms, station area, depots

Given that in spite of the principle prohibition, administrations still use pesticides for cemeteries, sports fields, landscaping, bedding of trams, railways and platforms, it is very likely that pesticides were used quite intensively before 2010 as well.

Little data is found regarding the private use of pesticides. Studies of tit chicks (see Section 2.2.3.5), among others, indicate that this use can also have a significant effect. The global sales figures of pesticides for Belgium per active substance can be requested via STATBEL. However, no distinction is made here between private or agricultural use, figures with this distinction can be obtained from Fytoweb (see Section 3.2.8). Figures for Flanders can be downloaded from the VMM website, however, no distinction is made between the different products, but only a global figure.

1.4.6 Shipping and ports

Biocides are also used in shipping and ports. Ships and hydraulic installations (bridges, locks, etc.) are treated to prevent damage by algae. For this, a coating is applied from which the biocide can leach into the water and the sediment. Organotin compounds have been used extensively for this purpose in the past. These substances have been banned since 2008 in anti-fouling applications.

1.5 PPCP: PHARMACEUTICALS AND PERSONAL CARE PRODUCTS

Pharmaceutical and personal care products (PPCP) form a class of "*emerging contaminants*". There are more than 4,000 pharmaceutical and chemical products, such as medicines, cosmetics, perfumes, and dietary supplements that are common in many households. (1)

1.5.1 Agriculture and livestock farming

Livestock farming can be a source of soil contamination with pharmaceuticals. Livestock urine and faeces can contain parasites and drug residues that can accumulate in the soil (1).

The VMM has already conducted studies into the emissions of medicines from veterinary use into surface water. In a first study, 100 fertilizer samples from slurry houses were analysed f (see also Section 2.2.6). In a second study, an attempt was made to quantify the amount of antibiotics that were brought onto the land and that subsequently end up in surface water (41). In veal calves, higher concentrations of antibiotics and more different types were found than in the other samples.

1.5.2 Waste water

Most of the PPCP used by humans is expected to end up in the environment through waste water (42). A study was conducted in Norway and Sweden where analyses were carried out on pharmaceuticals, hospital antibiotics, contrast media, personal care products and medicines from aquaculture in samples of hospital waste water, water treatment, seawater, marine sediment and mussels. (43)

VMM conducted an exploratory study into the presence of medicines in the water chain (44). in this Sstudy this, 26 substances were analysed in the waste water of households (influent and effluent from WWTPs), hospitals and companies from both the pharmaceutical and non-pharmaceutical sectors. Surface water used for the production of drinking water and the drinking water itself were also examined. In addition, an inventory was drawn up of sources of medicines in surface water. Households are the most important source (> 90%). Hospitals come second.

An example of a widespread PPCP is Triclosan. This is a powerful and widely used bactericidal and antifungal agent that is used intensively as a disinfectant and preservative in many products; for example in cosmetics (deodorants, soaps, shampoos, make-up, toothpaste) cleaning products, food packaging materials, oral hygiene products, shoes, carpets, textile materials (stockings and underwear), etc. A possible decomposition product of triclosan is chlorine dioxide. Triclosan has structural similarities to non-planar ortho-PCBs. The substance is difficult to break down in the environment. It is found in many settings, including water treatment plants and lakes. (23)

1.5.3 Aquaculture

A study from Norway and Sweden (43) also lists aquaculture as a possible source of medicines in waste water. In Flanders too, there are a limited number of companies that practice Aquaculture. It is expected that any contaminants can mainly spread to the environment via waste water.

1.5.4 Drugs (waste)

A specific problem where diffuse contamination with PPCP can occur is the illegal dumping of drugs waste. Increased concentrations of certain drugs can also be detected in waste water in regions with heavy use (EMCDDA, 2016). This may also include temporary locations where the risk of use is high, such as waste water from festival sites, which sometimes still ends up directly in waterwaywaterways. There are a few initiatives to connect this water to the sewer system or to purify it on site (VLAKWA, Aquafin).

1.6 POLYCHLORINATED DIBENZODIOXINS (PCDD) AND POLYCHLORINATED DIBENZOFURANS (PCDF)

Emissions of dioxins into the air are a major source of environmental contamination. In areas close to point sources of dioxins, deposits can be up to 10 times higher than in urban areas. (45)

1.6.1 Natural presence

Natural sources of dioxins in the environment are volcanic eruptions (1) and forest fires. (45)

1.6.2 Combustion processes

Dioxins are produced in small concentrations when organic material is burned in the presence of chlorine.

Combustion sources include household or medical waste incinerators and barrels in which waste is burned (“backyard barrel burning”). Other thermal sources include incinerators for solid and hazardous waste, metal processing plants, coal and oil industry, electricity power stations, sintering plants, cement, glass and brick factories and recycling plants. (45)

Households are largely responsible for the diffuse emissions of dioxins. Wood stoves and heating systems produce dioxins as a by-product, even if they are used properly. (46)

The first inventory of dioxin sources, made by the US EPA in 1987, showed that 80% of the known dioxin sources were combustion processes. The combustion of household, medical, sludge and hazardous waste currently accounts for less than 3% of all dioxin emissions. However, since 1987, private waste management ("Backyard barrel burning") has barely declined, making it now the largest source of dioxins in the United States, accounting for 1/3rd of total emissions (45).

In Flanders, too, households are responsible for the largest share of dioxin emissions and, as with PAHs, this is mainly due to wood burning. The ban on incineration in open fires and barrels in Flanders reduced the emissions of PCDD/F from this source between 2000 and 2016.

As mentioned earlier, coal ash from coal burning in stoves also contains heavy metals, PCDD/F and PAHs. These ashes were often used in gardens in the past. Even now, the use of ash from (wood) stoves is recommended as a fertilizer on various gardening forums. Given the widespread use of coal stoves in Flanders in the past, it is likely that in many places these ashes have ended up in the soil and thus form a source of diffuse soil contamination. In the meantime, the Flemish government has launched campaigns: https://www.vlaanderen.be/stook-slim-en-vermijd-luchtvervuiling.

Next to households, industry is the second largest source of PCDD/F. However, emissions in this sector halved between 2000 and 2016. Traffic is the third largest source followed by the trade and services sector. Industrial waste incineration, in particular, causes the most emissions in this sector. However, there was also a decrease between 2000 and 2016 due to new techniques and flue gas purification.

Crematoriums also emit PCDD/F. However, these emissions have fallen sharply due to the installation of permanent flue gas treatment (45) (6). As a result, total emissions from the trade and services sector fell from 12 g TEQ to 0.6 g TEQ. (6)

1.6.3 Industrial processes

Dioxins can also be produced in non-combustion reactions such as bleaching paper fibres with chlorine. Historically, the pulp and paper industry has been a major source of PCDD/PCDF by chlorinating phenolic components in wood. These components were frequently present in waste water and sludge. While most industrialized countries have now stopped using elemental chlorine for bleaching, contamination from past activities is still present. (45)

In addition, dioxins are formed in the production of chlorinated chemicals such as PCBs, phenoxy herbicides, chlorinated benzenes, chlorinated aliphatics, chlorinated catalysts and halogenated diphenyl ethers (45). An example of such a component is the wood preservative pentachlorophenol, and also herbicides such as 2,4-dichlorophenoxyacetate (2.4-D) and 2,4,5-trichlorophenoxyacetate. The main industrial source, however, is the ferrous industry. (23)

Figures from the IMJV and air measurements from VMM also show that the chipboard industry produces significant dioxin emissions.

1.6.4 Decomposition of chemicals

Dioxins can also be produced by the photochemical breakdown of triclosan, a well-known antimicrobial agent.

1.6.5 Landfills

(Unregulated) landfills, where dioxin-containing waste was dumped, are also potential sources. (45)

1.6.6 Agriculture

Agricultural land on which chlorinated pesticides have been used, which may contain traces of dioxins and dioxin-like components, can also be contaminated with dioxins. However, the impurities were likely to be very small and highly regulated, making contamination by the pesticide itself more worrying (45). The use of contaminated sludge and soil improver can also spread these substances further into the environment.

1.7 POLYCHLORINATED BIPHENYLS (PCB)

Polychlorinated biphenyls were once often used as dielectric and cooling fluids in electrical appliances, carbonless copy paper and in heat transfer fluids. The bromine analogues of PCB are polybrominated biphenyls (PBBs). These have similar applications and also similar environmental problems (see also Section 1.8).

These substances have excellent electrical insulation capacity, excellent fire resistance, suitable heat conduction and viscosity. Because of these qualities, PCB-containing devices and materials became widespread With the discovery of the environmental damage that PCBs can cause and their classification as persistent organic contaminants, their production was banned by the United States in 1978 and by the ‘Stockholm Convention on Persistent Organic Contaminants’ in 2001. Due to their low vapour pressure, PCBs mainly accumulate in the hydrosphere and in the organic fraction of the soil. (46)

PCBs are mainly known for their use in transformers. The OVAM keeps an inventory within the framework of the Flemish PCB removal plan. This contains 20,175 PCB-containing devices that contain more than 500 ppm of PCBs. To date, 99.80% of this has been removed for processing. The devices that have not yet been removed are monitored by the Environmental Inspectorate. In addition, there are also 73 devices included in the inventory whose PCB content in the liquid is less than 500 ppm. These devices may remain in use until the end of their lifespan and only then have to be removed for processing as PCB-containing devices. The VMM's annual air report shows that this led to a decrease in PCB emissions. (47)

Based on the VMM data, households in Flanders are responsible for the majority of PCB emissions.

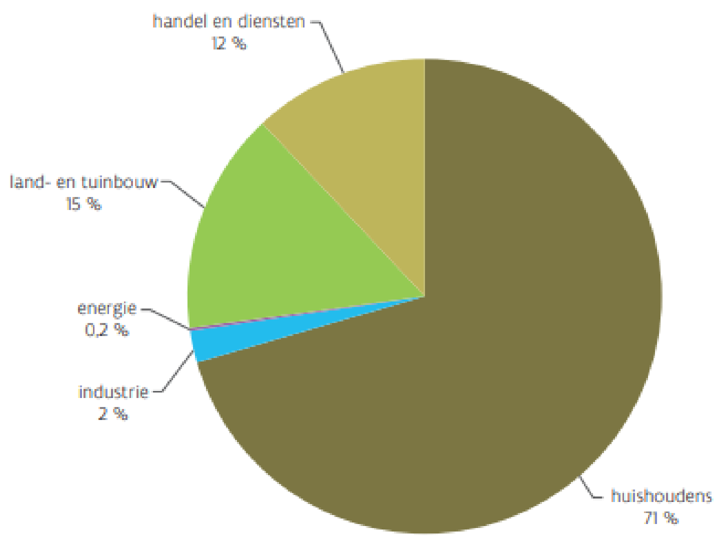


Figure1-9: Proportion of the various sectors in PCB emissions in Flanders in 2016 (%) (6)

The sections below list the sources of PCBs that may be relevant in the context of diffuse soil contamination. Given the widespread use of PCBs, these are not all possible sources.

1.7.1 Combustion processes

VMM's annual air report shows that in 2016 the total Flemish PCB emissions into air amounted to 413 g. Households made the largest contribution, at 71%, exclusively through building heating, mainly due to the combustion of coal. Agriculture and horticulture came second with 15%. These emissions were caused by fuel consumption. (6)

1.7.2 Electrical applications: cables, capacitors and heat exchangers

- (high voltage) cables: PCBs were incorporated into cables as a flame retardant. PCBs were added to the insulation of the cable or to the paint on the cable. Cables filled with PCB-containing oil are often found in power stations and other places where electricity is produced or transported. Underground cables can also contain PCB-containing oil. These cables fell under the so-called “closed system”, which means that such systems could not spread PCBs to the environment, which means they can remain in use longer. However, the cables often turn out to be only a closed system in theory. In Oslo, for example, it was necessary in 2012 to top up such cables with 7,000 litres of oil. (48)

- In the early 1970s, Ward B. Stone of the New York State Department of Environmental Conservation (NYSDEC) published his finding that PCBs leaked from transformers and had contaminated the soil at the base of electricity poles.

- Hydraulic oil: The largest use of PCB-containing hydraulic oil is in mining, the aluminium, copper, iron and steel industry, shipyards, foundries and military applications. Such oil was also used in aircraft, ships and submarines (48).

1.7.3 Construction materials

- In Germany and Switzerland acoustic ceiling tiles were used, impregnated with PCBs. These were widely used in schools. Similar tiles were produced and used in offices and shops in the United States. (48)

- PCBs have also been used in seals between concrete panels in buildings, bridges, and in seals between concrete and other building materials. Seals around windows, doors and swimming pools often contain 15-20% and exceptionally up to 50% PCBs. Brand names of this product include Thiokol, Thioflex, Vulkseal, Vulkfil, Lasto-meric, 1K, Terostat, PRC and Rubberseal. PCBs are also found in other types of seals. In a Swedish study, it was calculated that a 3-story building can hold up to 45 kg of PCB seals. About 50% of the insulating glass seals are still in use. An American study found that the PCB concentrations in soil samples around buildings with intact PCB-containing seals around the windows varied between 3.3 and 34 mg/kg. (49)

- Adhesives: Special adhesives to bond double-glazed glass to the aluminium frame may contain PCBs. Each window can hold up to 60 grams of PCBs. In Norway there is a collection system, whereby the producer of such windows is responsible for their disposal as hazardous waste. In addition, PCBs have also been used as plasticizers in special applications such as waterproof wallpaper and in adhesive in pipework. Adhesives for carpets, linoleum and panels can also contain PCB.

- Additive in concrete: Some brands of concrete containing PCBs are known in Norway. Brand names include “Borvibet”, “Elasticrete” and “Tranaved” (48). It was used in primers, floors, for repairing concrete surfaces, under linoleum, tiles and the like. PCBs are also found in terrace floors, cement adhesives for ceramics and in slates. PCBs are also found in conventional concrete in various concentrations and up to 55 mg/kg dw because the PCB-containing concrete types were sometimes mixed in here. In addition, PCB-containing coatings are also applied to concrete floors, aircraft floors and PVC floors.

1.7.4 Paint

PCBs were often used in paint. The first applications of this are probably coatings on the metal bows of ships. PCBs prevented paint from cracking, and prevented rust and algae growth. The use has spread and, amongst others, the following applications can be found in the literature: ships, other metal objects such as pipes, steel bridges, silos in agriculture, power lines, hangars for aircraft, nuclear power stations, non-slip floors in the food industry, hospitals, industry, balconies and stairs, stables, swimming pools, toilets, especially in schools, floor paint, cellars, eternite plates, gas tanks, oil tanks, canal locks.

1.7.5 Plastics

PCBs were used as an additive in PVC. (48)

1.7.6 transportation

PCBs were also used in lubricating oils. Another transport-related application is plasticizer in rubbers and seals that were also used in vehicles. Some sources also mention the use of PCB in asphalt.

1.7.7 Scrap companies

Scrap companies emit a lot of diffuse particles to which mainly PCBs but also dioxins are bound (46). The VMM therefore measured the highest PCB depositions in industrial areas where scrap companies are located.

1.8 FLAME RETARDANTS

Flame retardants are a very diverse group of chemicals. These products are added during the production process to, for example, plastic for use in computers, cars, television sets, textiles, insulation material, carpets, curtains, packaging material, coatings and paints, construction material, solvents and lubricants. Flame retardants are often mixed with a polymer and can leach into the environment during their lifetime. (50)

The classes of flame retardants that currently require the most attention from an environmental toxicological point of view are the brominated flame retardants (BFRs), organophosphorus esters (PFRs, Phosphorus flame retardant) and chlorinated flame retardants (CFRs).

Different subclasses can also be distinguished here. We distinguish four main types of BFRs:
- polybrominated diphenyl ethers (PBDEs),
- tetrabromobisphenol - A (TBBP-A) & derivatives,
- hexabromocyclododecane (HBCD; a complex mixture of different enantiomers),
- the now no longer produced polybrominated biphenyls (PBBs).

Organophosphorus esters can be divided into two types.
- The halogenated components are used as flame retardants
- The non-halogenated components are usually used as plasticizers in plastics.

The first generation of **brominated flame retardants, the polybrominated biphenyls (PBB)** have been used since the 1970s. They were followed by the PBDEs, mainly penta- and octa-BDE mixtures (51). Their use was widespread and in 2001, 67,000 tons were sold worldwide each year. PBDE and PBB production ceased in the USA in 2013. A few brominated flame retardants were included in the POP convention. In view of these legal restrictions, new, often also brominated, flame retardants are being developed, the so-called “emerging” brominated flame retardants. There are indications that PBDEs and HBCDD are gradually being replaced by DBDPE in the environment (52). This substance has also already been found in sediment of the Western Scheldt (53) (54)(see also sections 2.1.3.3 and 2.2.3.5).

The heating and/or uncontrolled combustion of halogenated products containing PBBs, PBDEs or other brominated flame retardants could lead to the formation of polybrominated dibenzo-p-dioxins and dibenzofurans. (54)

Organophosphate esters have been used mainly since the 1970s as a flame retardant or as a plasticizer (51). Norway performed a screening of organophosphate flame retardants in the Norwegian environment in 2010 (50). The results showed that most PFRs were found in sediments from urban and remote areas, with concentrations higher in sediments from urban areas. Sediments are an important sink for PFRs. In general, biota (crabs, mussels, fish and birds) had low internal concentrations of PFRs. As with most of the chemicals introduced by humans, the PFRs are mainly found in the environment near human activities.

Chlorinated flame retardants
Dechlorane plus (DDC-CO) or bis (hexachlorocyclopentadiene) cyclo-octane is a chlorinated flame retardant that has been used since the 1960s. This substance also occurs globally and can bioaccumulate (51). Three other chlorinated flame retardants produced by the same producer have also been found in the soils of arctic regions, although even less data is available for these substances.

Gebromeerde vlamvertrager	CAS nummer
Gebromeerde polystyreen	88497-56-7
Decabroomdifenyl ether (DeBDE)	1163-19-5
Hexabroomcyclododecaan (HBCD)	25637-99-4
Ammonium bromide	12124-97-9
Ethaan-1,2-bis(pentabroomfenyl)	84852-53-9
Tetradecabroomdifenoxy benzeen	58965-66-5
(Poly)pentabroombenzyl acrylaat	59447-57-3; 59447-55-1
TBBP-A bis(2,3-dibroompropyl ether)	21850-44-2
Tetrabroombisfenol-A (TBBP-A)	79-94-7
Tris(2,3-dibroompropyl) isocyanuraat	52434-90-9
N,N´-Ethylene bis(tetrabroomftalimide)	32588-76-4
TBBPA carbonaat oligomer; 2,4,6-tribroom-fenol end-capped	71342-77-3
Polydibroomstyreen	148993-99-1
TBBP-A diglycidyl ether	3072-84-2
TBBP-A carbonaat oligomer, fenoxy end-capped	94334-64-2
Tris(tribroomneopentyl) fosfaat	19186-97-1

Figure1-10: Most used brominated flame retardants in Flanders (from high to low use) source: (54)

Phosphoroganic flame retardant	CAS no
tri-iso-butylphosphate (TiBP)	126-71-6
tributylphosphat (TBP)	126-73-8
tri(2-chlorethyl)phosphate (TCEP)	115-96-8
tri(1-chlor-2-propyl)phosphate (TCPP)	13674-84-5
tri(1,3-dichlor-2-prophyl)phosphate (TDCP)	13674-87-8
tri(2-butoxyetyl)phosphate (TBEP)	78-51-3
tris(2-ethylhexyl)phosphate (TEHP)	78-42-2
triphenylphosphate (TPhP)	115-86-6
2-ethylhexyl-di-fenylphosphate (EHDPP)	1241-94-7
tris-o-cresylphosphate (ToCrP)	78-30-8
tricresylphosphate (TCrP)	1330-78-5
Dibutyldiphenylphosphate (DBPhP)	2528-36-1
Butyldiphenylphosphate (DPhBP)	2752-95-6
Tetrekis(2-chlororethyl)dichlorisopentyldiphosphate (V6)	38051-10-4

Figure1-11: Often used PFRs (50)

Abbreviation	CAS number	Chemical name	Other abbreviations commonly used in the literature
DDC-CO	13560-89-9	Dechlorane Plus; Dechlorane 605	DP
DDC-DBF	31107-44-5	Dechlorane 602	Dec 602
DDC-Ant	13560-92-4	Dechlorane 603	Dec 603
HCTBPH	34571-16-9	Dechlorane 604	Dec 604
$aCl_{11}DP$		Undecachloropentacyclooctadecadiene	
$aCl_{10}DP$		Decachloropentacyclooctadecadiene	
DPMA		Dechlorane Plus monoadducts	

Figure1-12: Chlorinated flame retardants (51)

1.8.1 Textile and plastic industry

In Sweden, the textile and plastics industry were the main sources of brominated flame retardants in the environment. (54). Brominated PBDEs and HBCD as well as PFRs are bioavailable from sediment, as demonstrated by their presence in fish (see also Section 2.2.3.3). The presence of BFRs in fish has been associated with companies using or producing brominated flame retardants. The River Tees in the UK was shown to be heavily contaminated by PBDEs downstream from a PBDE producing company. A similar observation was made on the Scheldt in the Netherlands/Belgium. This probably does not involve BFR-producing factories, but large consumers, such as the textile industry upstream. (54)

1.8.2 Household sources

The presence of fire retardants in sludge from water treatment plants indicates that these substances can also be found in household or other diffuse sources. (54)

1.8.3 Plasticizers and lubricants

The non-derivatized alkyl phosphates such as tributyl phosphate (TBP), tri-iso-butyl phosphate (TiBP), triphenyl phosphate (TPhP) and tris- (butoxyethyl) phosphate (TBEP) are mainly used as plasticizers and lubricants but are also used in some cases as flame retardants. (50)

1.9 PLASTICIZERS

Bisphenol A (BPA) or phthalates and phthalate esters (PAEs) are often used as plasticizers and are found in many products such as lubricating oils, car parts, paints, adhesives, repellents, photographic films, perfumes and (food) packaging materials.

PAEs and BPA are common in agricultural land close to urban areas and suburbs, and originate from sewage sludge, the use of plastic film in agricultural activities, the use of urban waste water as irrigation water or atmospheric deposition. (1).

Based on the report "Chemicals in European waters" (55), one of the most widely used phthalates is DEPH (bis (2-ethylhexyl) phthalate). This was often incorporated into PVC, including PVC drinking water pipes, making it a source of DEPH into the environment for many years to come.

1.10 PFAS

The PFAS family includes 42 subfamilies and several thousand substances. The main ones are (56):

- Perfluorinated compounds
  - Perfluorinated sulphonic acids, including perfluoro-octane sulphonic acid (PFOS),
  - Perfluorinated carboxylic acids, including Perfluoro-octanoic acid (PFOA),
- Polyfluorinated compounds
  - fluorotelomers
  - Precursors
- Fluoropolymers

Perfluorinated compounds have been produced and used since the 1950s (51). They are not or hardly biodegradable, accumulate in the food chain and are found worldwide in biota (penguins, polar bears, fish, etc.) (23).

For a detailed overview of international standards and literature, reference is made to the report "Research into the presence of PFAS in groundwater, soil and sediment at risk activities in Flanders, OVAM, 2018".

1.10.1 Firefighting foam

PFAS-based firefighting foams have been used since the 1970s to extinguish fires at airports, refineries, bulk chemical storage and other locations where large volumes of flammable liquid hydrocarbons are used. This foam is also used in firefighting training at these locations and can be released during testing and use of automatic fire extinguishing systems in buildings. (56)

1.10.2 Industrial sources

Potential industrial sources of PFAS are primarily the production locations of PFAS. In addition, PFAS are used in the production of polymers (including Teflon, mainly PFOA).

Another industrial application is electroplating, more specifically, chrome plating. PFAS are also used for making paper, textiles (clothing, shoes, tents, carpets, furniture) and leather (mainly PFOS) grease and water resistant (23). (56)

1.10.3 Household sources

Household sources of PFAS include PFAS-treated textiles, paper and other household uses such as cleaning products, insecticides, lubricants, paint, varnish, non-stick pans and cosmetics including sunscreen and body lotion. (56)

1.10.4 Transportation

PFAS were also used in plastics, textiles and lubricants for means of transportation (cars, planes, trains, etc.). (56)

1.10.5 Landfills, waste water, waste incineration plants

Landfills, waste water and waste incineration plants can also be sources of PFAS.

1.10.6 Overview of risk locations

PFAS are produced and processed at various locations. The risk of environmental contamination depends on the quantities used and under which conditions the compounds have been handled or processed.

The table below gives an overview of risk activities where there is a chance that PFAS will be released into the environment.

Table 1-2: risk activities where there is a chance that PFAS will be released into the environment

Location type	Subcategory	Activity	Risk of PFAS being released into the environment (soil, groundwater, sediment, air)
PFAS producing industry	Producers	Production of PFOS/PFOA, telomers	large
Manufacturing industry	Teflon production	PFOA used during production	large
	Galvanic industry	Mist suppressant (misting, chrome baths), especially in chrome processing industry (but also other metals)	large
	Textile industry	Treating textiles, leather, making water-repellent, misting For example, carpets, furniture upholstery, outdoor clothing, shoes	limited
	Semiconductor industry	Use of PFAS in printed circuit board production (suspected products/chemicals: photoacid, anti-reflective coating, photoresist and developer fluid).	Limited
	Photo industry	In the photo industry, products such as solvent, pigments, developing fluid were also used.	Limited
	Paper and Packaging Industry	PFAS has been/is being added to the composition of the paper to make it water and grease resistant (as with food packaging, baking paper, etc.)	Limited
	Paint Industry	Paint production using PFAS	Limited

Location type	Subcategory	Activity	Risk of PFAS being released into the environment (soil, groundwater, sediment, air)
	Hydraulic fluids	PFAS as an addition to hydraulic fluids used in filling and refilling the fluid since at least 1970. Main use in aircraft construction and maintenance.	Limited
	Manufacture of cosmetics and cleaning products	Mainly used to reduce surface tension or to extend the life of mainly cosmetic products	Limited
	Fire extinguishing	Emergency	Large
	Fire service training places	Regular, long-term use of, for example, PFAS-containing foam	Large
Firefighting foam use (AFFF) (1970-2011/present)	Fire services (industry)	During emergencies and/or tests. Chemical industry, storage and transhipment locations, car industry, plastics industry, waste and scrap processing companies, wholesale chemicals	Large
	Military training sites and airports	During emergencies and/or firefighting exercises	Large
	Airports (civil aviation)	During emergencies and/or firefighting exercises	Large
Landfills		Decomposition material in landfill (e.g. treated textiles, paper), leaching from landfill	Limited
Water treatment plants		Mainly water purification from industry	Limited
Waste incineration plants		PFAS are broken down but probably not completely - cannot be excluded as a potential source	Limited

PFAS may be widespread in the soil. PFAS were also detected in remote arctic soils (order of magnitude ng/g wet weight) (51).

1.10.7 Fertilizers and compost

A possible secondary source of PFAS in the soil is fertilizers such as compost, digestate and sewage sludge. A 2019 study in Germany examined 201 samples of waste water sludge and 45 samples of biological waste for the presence of 14 different PFAS. The results show that the sludge acts as a sink. From these results it was calculated that spreading this sludge over agricultural land results in an annual distribution of 145 kg PFAS over German fields. To estimate the possible effects on groundwater, 364 monitoring wells were sampled for 7 years and the concentration of 21 PFAS was determined. (32,800 measurement results). PFAS were found in 90% of the monitoring wells examined. PFOA and PFOS were found in 45% (mean 1.2 ng/l), the short chain PFAS in 29% (mean 0.7 ng/l) and the long chain PFAS in 5% (mean 0.07 ng/l) of the samples. (57)

A United States study analysed the leachability of 17 PFAS in 9 different compost types from the organic fraction of household waste, as well as 1 type of garden compost. The results ranged from 28 to 75 µg/kg for compost containing food packaging and from 2.3 to 7.6 µg/kg for compost containing no food packaging (58). In principle, it is not allowed in Flanders to throw food packaging into the organic waste container.

Widespread contamination with PFAS has been identified in the Baden-Baden region of Germany since 2013. The cause may be paper sludge that was applied as compost to agricultural land. Approx. 700 hectares of land were examined. Increased concentrations of PFAS were detected in 400 hectares. More than 1900 groundwater samples, 1300 soil samples and 1000 soil eluate samples were analysed. A groundwater model was also drawn up, which can be consulted online: https://www.lubw.baden-wuerttemberg.de/wasser/pfc-karten-online

Since 1992, Vlaco has been controlling companies that process organic biological waste into raw materials in or as a fertilizer or soil improver in Flanders. This quality control results in an inspection certificate, which gives additional guarantees to the customer, also in other European Member States. Compost producers can also voluntarily commit to the Vlaco label, an extra label for compost. In November 2016, almost 200 test certificates were issued among the certified companies. In Flanders there are forty professional composting installations. Some only process organic waste, others only green waste. .

The award of the test certificate is a control mechanism to prevent unacceptable diffusion of unwanted and/or contaminating substances by using waste materials as fertilizers or soil improvers on Flemish soil.

According to the general certification regulations (OVAM), the compost must be analysed for heavy metals, PAH, tetrachlorobenzene, pentachlorobenzene, hexachlorobenzene, MO, sum PCB (7), but not for PFAS to obtain the test certificate.

1.11 ASBESTOS

1.11.1 Natural occurrences

Asbestos occurs naturally in soil with ultramafic rock, mainly serpentine and amphibole (1). However, this rock is not present in Flanders.

1.11.2 Building materials and utility lines

Due to its fire-resistant properties, asbestos was frequently used in fire-retardant insulated supporting structures and technical rooms: walls, floors, ceiling, doors, pipes, boilers. Asbestos also occurs in roof and wall cladding, downspouts, window boxes, floor coverings, joinery, etc.

Asbestos waste (mainly asbestos cement applications) from careless demolition of buildings and structures, and from the break-up of roads and pavements often ended up in the soil or in the construction rubble. As a result, collections of soil and rubble become diffusely contaminated with asbestos. Raised layers with asbestos production waste also result in a further diffuse distribution of the asbestos material in case of careless earthworks.

When weathering roof elements and facade cladding containing asbestos are found, asbestos is also found in the soil at the rainwater drip areas. Fire in buildings containing asbestos also create a diffuse spreading of asbestos.

Utility pipes were also made of asbestos-containing material (asbestos cement) and can weather.

1.11.3 Road and driveway foundations

In the region where asbestos processing companies (Eternit, Alfit) were located, asbestos was frequently used as a fill or raising layer. Asbestos cement millings (milling residues of asbestos cement pipes), asbestos cement plates (cutting residues, asbestos cement, slates and plates) but also asbestos cement sludge are therefore widely found in driveways, roadsides, utility lines, wells, dikes, water sediments and field roads.

1.11.4 Trains and cars

Asbestos was also used in the production of brakes, seals and other friction materials in various means of transport such as cars, trains and aircraft. Usually this concerns chrysotile. 1% of such parts were found in Belgium. (59) (60)

In the past, asbestos has been used in all kinds of applications in different types of cars. In most cars, this concerns asbestos brake linings and clutch plates. In addition, asbestos often occurs in gasket materials such as plate gaskets in engines. Around the exhaust system, asbestos was regularly used in heat shields. In some models, asbestos has been used as an insulating material against the underside of the bonnet. Asbestos can also be mixed into plastic and plastic parts. In exceptional cases, asbestos has been incorporated into upholstery and/or floor mats. In the 1930s, a car was even designed where the entire body was made of asbestos-containing sheet material. (59) (60)

Asbestos-containing brake pads also disperse asbestos fibres into the surrounding air. This can produce high concentrations of asbestos fibres, especially in parking garages and tunnels. Outdoor measurements were carried out by the TNO as early as the 1980s. This showed that in large cities, especially at intersections, the concentration of asbestos fibres was much higher than in rural areas. The highest concentrations were measured in the IJ tunnel in Amsterdam, where concentrations of up to 80,000 fibres per m³ were measured. That is 40 times higher than the current theshold value in the Netherlands.The main cause was the presence of asbestos-containing brake and friction materials in the vehicles that used the tunnel . (59) (60)

1.11.5 Sediments and dredging sludge

Sediments and dredging sludge from docks, rivers and canals may also contain low concentrations of asbestos, especially if they come from urban areas. In the past, this dredging sludge was regularly used to raise nearby plots and redevelopment sites. (59) (60).

1.12 NANO- AND MICROPARTICLES (NMP)

1.12.1 Micro- and nanoplastic

1.12.1.1 General

Several studies on micro- and nanoplastics recently made the media. For example, reports appeared that microplastics were observed in remote areas of the Pyrenees and Arctic ice.

In 2019, a SAPEA review was published on current knowledge of the impact of nano- and microplastic contamination on health, the environment and society (61):

Microplastics are defined as plastic particles smaller than 5 mm. Particles smaller than 1 or 0.1 µm are called nanoplastics. Micro and nanoplastics can be divided into 2 groups:

- the primary nano- and microplastics that are purposefully produced for a particular application (e.g. microbeads)

– secondary nano- and microplastics resulting from the breakdown of larger pieces of plastic. Some biodegradable plastics also contribute to the creation of these secondary nano- and microplastics, since they are not fully degradable under natural conditions.

Microplastics are observed in air, soils, fresh water, drinking water, oceans and in food products such as seafood, fish, table salt, beer and honey. However, there is a lack of standardized data and standardized analysis methods for nano- and microplastics for all environmental compartments. The study shows that there is knowledge about concentrations of microplastic in fresh water and oceans. However, there is much less data on air and soil.

The main sources of nano and microplastics in the environment are:

- **plastic waste:** The decomposition of larger pieces of plastic into micro and nanoplastics is one of the most widespread sources.
- **Cosmetic products**: Microplastics are often consciously produced and used in cosmetic products such as shower gel and scrubs (micropearls) and are released into the environment via waste water.
- **Synthetic textile**: Synthetic textiles and clothing are a major source of microplastics. Friction during washing and exposure to detergents cause the synthetic fibres to break down into smaller microfibers. These also spread via the waste water into the environment.
- **Urban dust**: House and urban dust, created as a result of the weathering of plastic objects and “spills” is another source.
- **Car tyres**: Tyre wear is also a major source of the release of microplastics and possibly nanoplastics

The relative importance of these sources for the microplastics discharged by rivers into the sea in Europe was estimated as follows:
- Car tyres: 42%
- Textiles: 29%
- Household dust: 19%
- Personal care products: 10%

Data on soil microplastics is limited, but they have been found in several terrestrial ecosystems:
- In agricultural land in North America: 1 fibre/g soil
- In Switzerland: up to 55 mg/kg - 593 particles/kg soil
- In soil in China and Australia

The sources of microplastics in soils are not well known. It is likely that sewage sludge and animal manure used as agricultural fertilizers are a major source of microplastics in soil. It has also been established that synthetic clothing fibres remain in agricultural land for at least 15 years.

Microplastics are associated with various chemicals, which can have additional environmental and health effects. Almost all plastics contain additives such as UV stabilizers, anti-oxidants, plasticizers, dyes, fillers, etc. All of these substances have an effect on the decomposition rate and leaching properties of the plastics. In addition, advanced plastics also contain added inorganic nanoparticles such as organoclay, carbon nanotubes or titanium oxide, which further complicates the risk assessment.

However, the relative contribution of microplastics to human exposure to these chemicals is estimated to be small. For example, the worst case of consumption of 1 serving of mussels would lead to less than 0.2% of exposure through food to Bisphenol A, PCBs and PAHs. Microplastics are also found in bottled water and tap water. However, according to the WHO, this should not pose a health risk.

Even less data is available on nanoplastics, which makes it impossible to estimate the risks and impact. It is also not possible to measure concentrations of nanoparticles.

Various distribution pathways for microplastics are known:

- **atmospheric deposition**: Microplastics occur in indoor and outdoor air. In Paris, atmospheric deposition was measured from 2 to 355 particles/m²/day. This results in 3-10 tons of plastic per year for all of Paris. Particles from tyres make up a significant part of the microparticles in air. The other sources and distribution pathways to air are not well known. Aerosols formed above the sea are a potential pathway, as is the blowing of dried sewage sludge on agricultural land. Other potential sources of air dispersion include drying clothes, air conditioners and plastic films used in agriculture. The microplastics can therefore be inhaled. However, there is virtually no data available on the quantity of microplastics inhaled.
- **Waste water treatment plants**: microplastics have already been detected at various treatment stages of waste water treatment plants. Domestic waste water contains concentrations ranging from 10 to 107 particles/m³. Installations with a tertiary purification (post-filtration) can remove up to 97% of the microplastics. Nevertheless, the effluents generally continue to make a major contribution to the presence of microplastics in surface water. In the treatment plants, plastic together with other particles is removed via sedimentation and ends up in the sewage sludge. Since this sludge is used as fertilizer in many countries, it can spread from here to agricultural land. However, the size of this input is unknown.
- Nano- and microplastics can also spread from the water to the land (“beaching”) and be deposited in the sediment of waterwaywaterways and oceans. Nano- and microplastics in the water accumulate on beaches near the waterline. This was observed both locally and worldwide, including on remote beaches. There are also indications that they can be found in the vertical profiles of the beaches. They were also found on the water surface, in the water column and in the sediment of lakes, rivers and estuaries. Reported concentrations in fresh water range from single particles to thousands per m³. This also applies to sediments, where concentrations can reach thousands of particles/kg of sediment.

The atmosphere and soil are major source media for nano- and microplastics to surface water, but virtually nothing is known about transport mechanisms and mass fluxes in air and soil. It is also unknown via which mechanisms, over what duration and where plastic waste is ultimately broken down into nanoparticles. It is also not known how the occurrence of micro- and nanoplastics will evolve in atmosphere, soil, water and biota.

Preliminary risk assessments may indicate an ecological risk from these microplastics in some locations in sea water and sediments. Little is known about the human risk, but there is no evidence that there is a widespread risk to human health from microplastics.

Recently (2019), a study was started by the ILVO and the Royal Belgian Institute of Natural Sciences (RBINS-OD Nature) that maps out exactly how much and which types of plastic occur in Belgian fishing grounds and on beaches.

In Flanders, the ILVO has been collecting data on plastic on a voluntary basis for almost 10 years, which is hoisted on board research vessels within existing measurement campaigns focused on the state of fish stocks and the impact of human activities at sea. An initial rough interpretation shows that the amount of macroplastics found is increasing, that there are hotspot sites, such as the Zeebrugge Oost dredging discharge wall, where harbour sludge is brought in and where the flow has a settling effect. The RBINS-OD Nature concentrates on what washes up on Belgian beaches. They have noticed from previous analyses that the amount of waste washed up is not decreasing. The situation is also poor on the beaches, according to the evaluation of the European Marine Strategy Framework Directive. (62)

1.12.1.2 Compost, sewage sludge and digestate

Specific sources of micro- and nanoplastics in soil are compost, sewage sludge and digestate that are used as fertilizers. The concentration of plastic found in several studies worldwide varies between 2.38 and 1,200 mg plastic/kg for compost and between 1,000 and 24,000 plastic particles/kg for sewage sludge (63). In Flanders too, the regulations for the biodegradable waste container were recently (1/1/2019) amended. Coffee pads and tea bags should no longer be added to this fraction because they contain too much plastic. Plastic fruit and vegetable bags are also often thrown into the biodegradable waste container and eventually end up in compost (64).

A German study reported measurements of between 7,000 and 440,000 particles of plastic between 1 and 5 mm in compost. The concentration turned out to be particularly high for organic waste from families. The particles mainly consist of polystyrene or polyethylene, materials that are often used in the packaging of vegetables and other consumer items. Most particles could still be identified as parts of bags or packaging that accidentally end up in the green bucket.
Installations that only process organic waste from industry have a remarkably high concentration of polyester. These particles probably come from containers and materials used in the transportation of large quantities of fruit and vegetables. (65)

Only processing plants for energy crops, which are specially cultivated for the production of biogas, supplied biomass without plastics. Plants that work with animal manure also appeared to be doing very well. (65)
In order to place the digestate and compost on agricultural land, the producer must have a VLACO inspection certificate. As already mentioned, for this certificate an analysis is performed for heavy metals, PAH, tetrachlorobenzene, pentachlorobenzene, hexachlorobenzene, MO, sum PCB (7), but not for plastic to obtain the test certificate.

1.12.2 Other nanoparticles

The number of products containing nanoparticles has increased significantly in recent years. Nanoparticles are present in thousands of products.

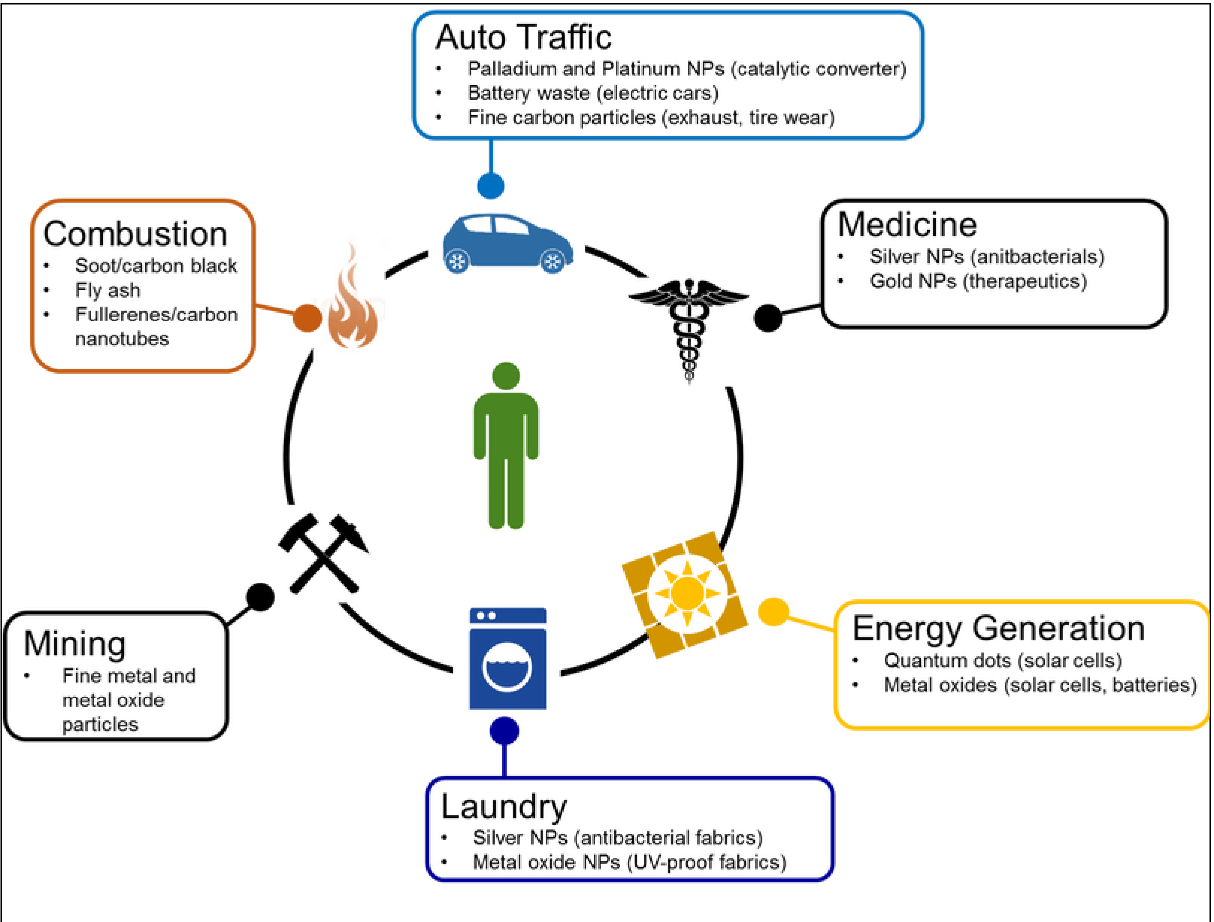


Figure1-13: Pathways by which human-made nanoparticles (NPs) are released into the environment (66)

1.12.2.1 Consumer products

Nanoparticles are used in many consumer products such as paints, cosmetics, textiles, paper, plastics, medication and food. (1).

During the use of products with nanoparticles, the weathering of the product is the main cause of nanoparticle release. For example, during the washing of clothing containing nanoparticles, major quantities of these nanoparticles can be found in the washing water.

1.12.2.2 Energy

Nanoparticles are used in solar cells and batteries. They are therefore a potential source. However, no data are available to demonstrate that environmental dispersion would occur with the use of solar panels and batteries. Possible emissions of nanoparticles are expected earlier in the production and processing (end of life) of these products.

1.12.2.3 Pharmaceuticals

Nanoparticles have many pharmaceutical applications.

1.12.2.4 Transportation
Nanoparticles are released during transport, for example in car catalysts and in car tyres. The batteries of electric cars also contain nanoparticles. Organic nanoparticles are also formed in combustion processes.

1.12.2.5 Waste
The release of nanoparticles during the use of consumer products is a major source. Many different waste (water) processing installations are confronted with nanomaterials in this way, without being specifically prepared for this. (67).

For example, there is a chance of emission into the atmosphere via waste incineration. However, studies have shown that the majority of nanoparticles after combustion can be found in the combustion ash, which in turn ends up in landfills.

5 to 30% of the nanoparticles in waste water still end up in the waterwaywaterway after water purification (67). However, the majority of the nanoparticles that end up in waste water treatment plants via waste water are found in the waste water treatment sludge. When this sludge is in turn incinerated, the ashes (and therefore also nanoparticles) end up in a landfill again. However, this sludge can also be used as fertilizer. A model has been developed in Switzerland to estimate how many nanoparticles are released into the environment (68). For the most produced nanoparticle in the EU (nano-titanium dioxide, estimated production of 39,000 tons/year), this model calculated that today the average concentrations of 61 µg/kg dw can be reached in soils through the use of sewage sludge as fertilizer. (68)

1.12.2.6 Soil remediation
Nanoparticles such as metallic iron powder are also used in soil remediation (injection of nano-iron, etc.) (1) and thus end up directly in the soil.

1.13 RADIONUCLIDES

1.13.1 Burning of coal - concrete and cement industry

In the combustion of coal, the mineral substances are largely concentrated in fly ash and bottom ash. In this way, the radioactive uranium and thorium naturally present in the earth's crust are concentrated in the fly ash. The fly ash is used as an alternative to replace cement in the production of concrete and stabilized sand. When using fly ash in building materials to replace natural products, such as clay (bricks) and sand (concrete, sand-lime brick), the radiation load in residential environments can increase. Typical concentrations of radium and thorium in such a fly ash are between 100 and 300 Bq/kg, depending on the coal used. These concentrations are quite low and pose few problems. In Flanders (and Wallonia) many landfills of fly ash occur, with an inventory of millions of m³. (69)

In Flanders there is no more production of fly ash as the last coal-fired power stations in Belgium were closed in 2016. Fly ash from former power stations is still available. For example, there is the Hainaut slag tip in Wallonia, which consists of 1.7 million m³ of fly ash that is currently being excavated. fly ash is also imported from outside Flanders, such as from the Netherlands, Germany, France and Italy. According to the 2015 annual report of the Monitoring of Sustainable Surface Minerals, the imported quantity in 2015 was 48 kton (mainly from the Netherlands; 45 kton). In

2015, 192 kton of fly ash was used in Flanders to produce lean and ready-mixed concrete. 53 kton were used as a soil improver by soil cleaning centres to replace lime.

1.13.2 Phosphate industry

The main source of increased concentrations of natural radionuclides of industrial origin in Flanders is the phosphate industry. In 2001, an inventory study was conducted to locate the zones with increased concentrations. The inventory study also includes maps indicating the location of the known landfills.

Five companies that process or have processed phosphate ore have processed approximately 64 TBq of radium and 2.7 TBq of thorium since the early 1920s. Of this, 36.5 TBq of radium and 2.3 TBq of thorium went into about 48 million tons of gypsum. (69)

About 36 million tons of this are still stored on gypsum deposits in Flanders, just over 2 million tons were sold, about 10 million tons were discharged into the Scheldt. Almost 10 TBq of radium ended up in 2.4 million tons of calcium fluoride sludge, stored in landfills. (69)

About 13 TBq of radium was discharged into the Grote Laak and the Winterbeek, and a hard-to-estimate fraction of it is now in the valleys of those rivers. (69)

Finally, 6 TBq of radium and about 0.4 TBq of thorium ended up in fertilizers. Usually, the activity is diluted with respect to the ores used, with gypsum with a factor of 1.6, with fertilizers with a factor of about 3. In the case of calcium fluoride sludge, a concentration occurs by a factor of 3 to 8 depending on the production process. In the contaminated valley soil of the Grote Laak and Winterbeek radium concentrations, which are sometimes more than 10 times higher than those of the ores, occur due to years of accumulation. (69)

Remediation is already ongoing at the Winterbeek. A soil survey is also currently ongoing at the Grote Nete (OVAM and FANC), an extension of the Grote Laak. A similar contamination was found here.

The total area occupied by known gypsum dumps is approximately 165 ha, a number of historical dumps in the Rupel region are missing, the location and surface of which are more difficult to determine. The sludge basins in Tessenderlo cover approximately 82 ha. In total, there are therefore about 247 ha of landfills in Flanders with increased concentrations of natural radioactivity as a result of the phosphate industry. The environmental contamination is mainly around the Grote Laak with about 12 ha, and the Winterbeek where an estimate of more than 200 ha does not seem excessive. (69).

In most cases, however, the radiological impact of the phosphate industry on the population is very limited. This is mainly due to the use that is currently being made of the areas with products containing radium or thorium. The radiation risk is dominated by the risk of radon gas seeping into buildings. In the present situation this occurs only very sporadically, with some reservations for the situations in the Rupel region and in the Molenstede region (Diest, Winterbeek).

Historical radium production in Olen also spread radium into the environment. A T landfill of 10 ha is present here and an additional environmental contamination that can be estimated at approximately 23 ha. The radiological impact of this is slightly greater when compared to the Winterbeek valley, without acute problems arising. This greater impact is mainly due to increased radon concentrations in a small number of homes, and the increased dose rates above some contaminated sites, for example along the Bankloop. (69)

1.13.3 Fertilizer

One of the end products in the phosphate industry was fertilizer. Quantities of radium and thorium got into the final product in dilute form (69). A few samples in 2000 showed that the fertilizer contained approximately 130-140 Bq/kg. To estimate the precise radiological impact of growing crops on soils fertilized with such fertilizers, one should have data on how much fertilizer is ultimately used per kg of soil, and what the transfer factors are for a particular type of crop. However, given that activity is low, the inventory study concluded that the radiological impact to the population is negligible (69).

1.14 SUMMARIZING MATRIX FACTORS AND SUBSTANCES

Appendix 1 contains a matrix summarizing the relationship between the various sources and substances.

2 MEASUREMENT DATA

This chapter collects existing measurement data that may be relevant in the context of diffuse soil contamination. This concerns direct measurement data from soil, groundwater and sediment in Flanders as well as indirect data from other media and regions. The inventory includes data and studies that show that the substances listed in Section 1 are found in the environment in Flanders. The data can confirm or refute certain relationships from Section 1. If interpretation of the data has already been done or is quickly possible, the possible connection with diffuse soil contamination is explained. It is indicated whether the data is freely available for further analysis. Finally, a matrix and data list (see Appendix 1) provides an overview of the parameters for which data are available in which study and lists the number of data involved, which format and who manages it.

2.1 DIRECT MEASUREMENT DATA FLANDERS

2.1.1 Soil

2.1.1.1 OVAM - soil surveys - Mistral - continuous supplementation of data

The largest database with analysis data of soil in Flanders is Mistral, OVAM's database. However, the data in Mistral comes almost exclusively from grounds with a risk activity, which include contaminants linked to risk activities on the one hand and general screening (strategy 1 of the OBO procedure) on the other. The data included in the context of the general screening of the site could be used in the context of diffuse soil contamination. However, it is not possible to select only these screening samples from the totality of data in this database. The Mistral database is made for managing files and delivering soil certificates. Therefore, automatic selection and filtering of certain data is not possible.

It may be possible to search for specific results by filtering on the assigned labels such as, for example, "drug related" or "asbestos". Or specific data from specific geographical regions can be selected and analysed (e.g. heavy metals around the metal industry in the Kempen region).

This database is continuously supplemented with new investigation results.

2.1.1.2 OVAM – WW1 heavy metals study – one-off study

In 2008-2009, 300 soil samples (0-30 cm bgl) were collected in the Ypres region for heavy metal analysis to determine whether elevated concentrations in the soil occurred in this region as a result of the First World War. The data from the samples was supplemented with data from the OVAM database (0-50 cm bgl) so that 720 data points were available with results for 8 heavy metals (As, Cd, Cr, Cu, Hg, Pb, Ni, Zn). To obtain a spatial image, geostatistical procedures were used in which prediction maps with a pixel resolution of 200 by 200 m were interpolated. These maps showed no regional patterns associated with World War I for arsenic, cadmium, chromium, mercury and nickel. Zinc, but especially copper and lead, were found to show a clear pattern that represents the former front zone (the "Ypres Salient"). For lead, the largest areas approximate the Vlarebo guideline values. (20)

The report of this study is freely downloadable. The raw data are not. This was a one-off study; the data are not being updated.

2.1.1.3 Database compiled in connection with revising the background values of heavy metals in soil - one-off study

In 2006, Vito conducted a study on the background values of heavy metals in Flemish soils. For this purpose, a database was compiled with 6775 metal analyses spread across Flanders. The data from this database came from:

- Verloo database + extra samples Tack et al. (1997)
- VITO database background values (Cornelis et al., 1993)
- OVAM database (April 13, 2005): extraction topsoil (0-30 cm)
- Grondbank database (25 November 2004): extraction topsoil (0-30 cm)
- VITO soil database for MIRA reporting Chapter Distribution of Heavy Metals

From this, 45 sampling locations were selected for performing additional analyses. The criterion on which the locations were chosen was the absence of human influence since the aim of the study was to determine background values.

It is not known whether this database still exists. This was a one-off study; the data are not being updated.

2.1.1.4 Soil management organisations - continuous addition of data

The accredited soil management organisations ("Grondbank and Grondwijzer") keep information about the origin, quality and destination of excavated soil materials. The purpose of the tracked data is mainly aimed at guaranteeing the traceability of the soil. Both organisations have part of this data available digitally, each in their own system.

A new earthworks regulation came into force since April 2019. Sludge and dredging sludge are now also covered by this regulation. Separate analysis results for soil samples were not digitized until April 2019. Since April, these data have to be submitted in XML format when submitting a technical report. However, the data is currently not being processed further.

The analysis results collected in a technical report mainly concern the parameters: clay, organic matter, pH, mineral oil, heavy metals and PAH. Since April 2019, more analyses on PCBs are also mandatory. For aquatic soils, this is supplemented with organochlorine pesticides. If other suspected parameters are expected in the soil to be excavated, analysis results will also be available. However, the number of results will be smaller.

The data from the soil management organisations is continuously supplemented with new results.

Grondbank data

Grondbank has recently started working with a new system for maintaining data. As a result, data is available according to the "old system" for the period from March 2006 to 18/12/2018. The new system was launched in 2019 and is being further refined. The data from 2006-2018 will also be imported into the new system.

Data is kept regarding the origin of the soil, any intermediate stops of the excavated soil (e.g. On a temporary storage location) and the final destination. In the context of the project towards diffuse soil contamination, the data about the origin of soil are particularly interesting. This concerns the following data:

- Type of the work e.g. sewerage works, environmental works, etc. The possible number of subjects will be expanded in the future.

- Location: When a technical report is drawn up, the address of origin is included in the declaration of conformity. In the new system this will be linked to Google locations so that an XY coordinate (Lambert) for the address point is known. in the old system, an XY coordinate was manually entered based on the technical report. In both cases, the XY coordinate concerns 1 point linked to the entire technical report, there is no split per bore, zone, part lot, mixed sample or depth. It only shows the address of the location of the technical report. Whether the cadastral parcels concerned can also be linked in the future is being investigated.
- The measurement table: environmental code with corresponding volume, description of the part lot and possibly phase of the works in which this lot is excavated
- the mineral test: the number of m^3 of excavated soil that can replace new mineral.
- XML files with analysis results linked to the XY coordinate have been available since April 2019. All results will therefore be linked to the same point.
- Presence of natural elevations for pH, chromium and arsenic, lambert coordinate, code, volume, depth, min. and max. concentration, always linked to the number of the declaration of conformity
- Presence of increased concentrations of PCBs, volume, tripartition code, influence on the code of PCBs, also linked to the unique number declaration of conformity.
- Land use
- Whether or not roads and sewerage works (is also indicated if, for example, a new road is being built on vacant land)

In the new system it is also possible to link tags to a declaration of conformity such as asbestos, PFOS, etc. which can then be filtered.

Regarding the destinations, the following information is known, via the unique number of the declaration of conformity, per batch: volume, date when admission of transport has been delivered (also unique number), address of origin, address of destination + type (concrete plant, road and sewer, etc.), client, etc.

Sediment is also included in the new system. In each technical report, whether it concerns sediment or soil will be indicated per sub-lot. The analysis results are also linked to the Google locations address point. There will be no digital data on exactly where the sampling point was located in the waterwaywaterway. Furthermore, the same data will be available as described above for origin.

In the past, sediment was not covered by the earthworks regulation. As a result, no (systematic) data is available from the pre-April 2019 soil database.

In the future it will be possible to know for which addresses cleared sediment has been laid on the bank and whether it has been drained or left lying after drainage.

Grondwijzer data
At Grondwijzer, too, the system of data collection and storage mainly focuses on traceability. Adjustments to the system are also planned at Grondwijzer as a result of the adjustment of the earthworks regulation on 1/4/2019.

Grondwijzer systematically and digitally has the following data regarding the origin of the soil:
- Address of origin and the XY coordinates of a central point of origin
- Type of works: Sewage works, utilities, construction projects, soil remediation project, etc.
- Destination type
- Client and expert
- temporary storage locations for soil or soil remediation center and if so which

- Checklist for each technical report in which it is checked whether all requested information is available.
- The measurement table: per part lot: type of soil material, volume and three-part code.
- Analysis results in XML will also be available from April 2019. Grondwijzer will archive these. If an XML from the lab is supplied (as currently planned), all results are linked to 1 XY coordinates.
- The checklist will be extended for, for example, asbestos: e.g. "were the rules of the asbestos guideline correctly followed?" and minerals test.

Analogous to Grondbank, it will also be possible to filter for sediment on what has remained on the bank after clearance.

Data maintained concerning the destination:

- Volumes permitted earth moving
- Volumes by quality
- Disposal of the soil: concrete plants, quay walls, etc.
- Inside or outside the cadastral work zone, as soil or for construction.
- Where soils go to (address or cadastral parcel or XY coordinate)
- Cadastral parcels can also be indicated for permitted earth moving (text field). Connecting to the government database is being investigated. Not sure yet.

Data is available from the establishment of Grondwijzer (15 years ago). Adjustments and expansions have been made over time. The measurement table, listing the environmental code and volume of each lot of soil, of each technical report has been available digitally since the start.

2.1.1.5 Mercury database Bonheiden, Haacht, Keerbergen, Rotselaar, Tremelo - one-off study

In 2015, VITO commissioned OVAM to compile a database containing data on elevated mercury values that were found in the Bonheiden, Haacht, Keerbergen, Rotselaar and Tremelo regions. The database contained known concentrations of heavy metals in the region, from soil surveys and files from Grondbank (285 files) and Grondwijzer (75 files). These data were supplemented with a sampling campaign. The database contains 12145 mercury records. The BSN type III was exceeded in various locations, including on non-risk land and agricultural land. The exceedance factors turned out to be rather limited: 1-5 x BSN III (70). The results were also incorporated in a map. A clear source of the elevated mercury concentrations could not be identified.
It is not known whether this database still exists. This was a one-off study; the data are not being updated.

2.1.1.6 INBO/Vlaamse Waterweg - DredGis database (inventory of dredging soils) - one-off study

In a study by the Institute for Forestry and Game Management in collaboration with the University of Ghent and the Catholic University of Leuven, dredging grounds along the Scheldt and the Leie were inventoried (1997-2002). Increased concentrations of metals were found in more than 80% of the 450 hectares of dredging soil. The contaminated river sediment used to be brought onto land by man during dredging, or was deposited by the river itself during floods.

The information was collected in a GIS data layer that is identified by geopunt but cannot be freely consulted or downloaded, only on request. The GIS file is part of a large database commissioned by the Ministry of the Flemish Community, Dep. LIN, Waterways and Marine Affairs Administration (AWZ). It contains the locations and land use of the dredging soils in Flanders (polygons), the places where soil samples were taken during the inventory and the analysis results of the soil and leaf samples. Data are currently available for the Upper Scheldt, the Zeeschelde, the Leie (+ tourist Leie +

diversion canal), the Yser (+ Ypres - Yser canal), the Durme and the Dender. The appropriate usage scale is 1: 10,000. (Geopunt.be)

- File format: Arc/Info Coverage
- Reference system: Belge 1972 / Belgian Lambert 72 (EPSG:31370)
- Parameters: Calcium carbonate $CaCO3$, Electric conductivity (EGV), Clay fraction, Clay fraction, Loss on Ignition (LOI), N, P, S, Al, Fe, Mn, Cd, Cu, Cr, Ni, Pb, Zn, Nutrients (Ca, K, Mg, Na) for steel samples, Organic carbon, pH acidity Method, Plant available P, Nitrogen, Sand fraction

In the period 2010-2012, the suspected sites along the Leie were reviewed by order of the Upper Scheldt Department (W&Z). First, it was investigated which (parts of) these sites are owned by W&Z and, where necessary, additional samples were taken and analysed for general soil characteristics and concentrations of macro elements and heavy metals. The soil was sampled according to a regular grid of 70 x 70 m^2. Sampling was always carried out to a depth of at least 2 m, unless the substrate did not allow this. In the 29 sampled sites, 467 soil samples were taken at 126 sampling points. The soil remediation standard was exceeded in 8 of the 29 areas. (71)

This was a one-off study; the data are not being updated.

2.1.1.7 INBO/Vlaamse Waterweg: sampling of flood control areas - one-off study

The soils of the flood areas checked along the Scheldt, Rupel, Dijle, Grote Nete and Kleine Nete are contaminated with heavy metals in a number of places. In the period 2005 to 2016, the INBO collected samples in 2,682 ha in 23 controlled flood areas of the Sigma Plan to evaluate the risk of any soil contamination. Soil samples were taken at almost 2,000 locations and the vegetation (willow, poplar, ash, alder, oak, maize and grass) was also sampled via leaf samples. A set of organic parameters was also analysed on 1/10 of the samples.
This was a one-off study; the data are not being updated.

2.1.2 Groundwater

2.1.2.1 Groundwater monitoring networks - continuous monitoring

- Primary monitoring network VMM
  The primary groundwater monitoring network consists of 860 filters that are evenly distributed over the various groundwater bodies in Flanders. Groundwater levels have been measured monthly since the 1980s. The monitoring network mainly consists of deeper measuring wells, used for quantity management, qualitative state monitoring and operational monitoring. The measurement frequency is **monthly for level measurements (since the 1980s) and annually for quality measurements (since 2000)**. The primary monitoring network has a different objective to the phreatic monitoring network. It was established to monitor the quality and quantity of groundwater resources. The filters are installed in aquifers that make a significant contribution to the water supply. That can be both strained and phreatic layers. Quality analyses are carried out on the filters of the primary monitoring network once a year. The parameters measured that are relevant for this study are heavy metals (As, Ni, Cd, Cr, Co, Cu, Pb and Zn). These are measured in approximately 600 filters of this measuring network, if sufficient freshening is possible during the sampling (5 x the water column). The number of measurement results per year therefore depends on the smooth flow into the monitoring wells. This database is continuously updated with new results.

- VMM phreatic monitoring network
  The installation of the phreatic groundwater monitoring network was started in 2003. In particular, the specific requirements of the Nitrates Directive make it necessary to investigate the diffuse distribution of nutrient concentrations in groundwaterin agricultural areas. The phreatic groundwater monitoring network consists of approx. 2000 wells, with a total of approx. 5000 filters and has been sampled since 2004. These are mainly shallow measuring wells in the first aquifer and mainly in agricultural areas, but also in nature reserves (numbers start with N /). The monitoring network is used for qualitative state monitoring and operational monitoring, the measuring frequency is twice a year for level measurements and quality measurements. Relevant parameters that are measured are cations, anions, heavy metals (As, Ni, Cd, Cr, Co, Cu, Pb, Zn and Hg), trichloroethylene and tetrachloroethylene. Measurement results have been available since 2005, although the composition of the analysis package has been adjusted several times over time.

  Pesticides are measured once a year by means of an LC-MS screening. Once a year, separate analyses are carried out on 18 specific pesticides (see the measurement data matrix in Appendix 1). For half of the measuring points, the LC-MS analysis is performed in the spring and the specific analysis in the autumn. This is the reverse for the other half of the wells. As a result, 1 annual result is available for the majority of substances.

  The analysis package may be expanded in the future (e.g. with PFAS or pharmaceuticals). However, no decision has been taken on this yet.

  The results of the groundwater monitoring network can be requested in bulk from the VMM for each groundwater body. This database is continuously updated with new results.

- WATINA monitoring network
  WATINA stands for “WATer In NAture” and is a database for hydrological monitoring in nature reserves. In this online database, data on water levels and the chemical composition of water in nature reserves can be entered and retrieved.
  This application came about through a collaboration between the Institute for Nature and Forest Research, the Agency for Nature and Forest and the MMIS.

  The monitoring network mainly contains data about groundwater levels. The levels are measured by volunteers. Physico-chemical analyses are available for a limited number of monitoring wells. However, the parameters analysed are of little relevance in the context of diffuse soil contamination (conductivity, pH, bicarbonate, phosphate, nitrate, ammonium, sulphate, chloride, potassium, calcium, iron TDS, O2, BOD, COD). This database is continuously updated with new results.

- DOV data
  There are various groundwater monitoring networks in Flanders. This data is also partly available via DOV.

  The main data included in DOV, however, concerns the measurement networks described above (VMM's primary and phreatic groundwater monitoring network and the WATINA monitoring network). In addition, there are also a number of monitoring networks that are not public.

For a better workability of the immense dataset of the groundwater monitoring networks in the Flanders Subsurface Database, every available measuring well, including the individual measuring filters (in the case of multilevel wells), has been assigned to a specific monitoring network. The following structure is used by DOV for this:

Table 2-1: monitoring networks for groundwater according to DOV

Monitoring network	Info	Number of measuring points in DOV	comments
monitoring network 0	origin/administrator unknown	Not public available through DOV	/
monitoring network 1	VMM Operational Water Management monitoring wells - primary monitoring network	912 filter available from DOV	/
monitoring network 2	VMM Operational Water Management department monitoring wells - uncertain quality	Not public available through DOV	especially deeper measuring wells (initially part of the primary monitoring network) with uncertain quality of measurement data and available well information - are indicative but are not kept in the context of reporting obligations
monitoring network 3	VMM Operational Water Management department monitoring wells - temporary monitoring network	401 filters available via DOV (varying depth)	used for temporary projects. For example, level measurements and analysis results can be found in the studies commissioned by the Water Department concerning the ecological inventory and vision formation of various river basins in the context of integrated water management. Other data sets are currently in preparation and will be systematically added to the database after quality control and depending on the confidentiality of the data.
monitoring network 4	monitoring wells of other Flemish and Belgian authorities or bodies	100 filters available via DOV	From a sample, these seem to come mainly from Ghent University
monitoring network 5	monitoring wells of drinking water companies	Not public	/
monitoring network 6	monitoring wells of private companies	Not public	/
monitoring network 7	groundwater extraction wells (pumping wells)	Not public	/
monitoring network 8	VMM Operational Water Management monitoring	5419 available through the DOV	/

Monitoring network	Info	Number of measuring points in DOV	comments
	wells - phreatic monitoring network		
monitoring network 9	monitoring wells of the Institute for Nature and Forest Research (INBO) and other nature organizations	Not public available through the DOV	/
monitoring network 10	wells that are constructed in VLAREM section 55	Not public	Vertical drilling for the construction of monitoring wells and for other purposes, other than those referred to in sections 53, 54 and 55.2; depth drilling);
monitoring network 10	wells that are constructed in VLAREM section 53.6	Not public	Construction of cold and heat pumps

The groundwater data is mainly managed by the VMM. Certain information from the non-public monitoring networks is also reported to VMM (e.g. by the drinking water companies). For more information about this, the VMM should therefore be contacted with a specific question.

In addition, the DOV mentions the existence of several other previous local groundwater monitoring networks, however these are not offered via the DOV:

- drinking water extraction control wells,
- monitoring wells of operators of major groundwater extraction and/or contaminating industries imposed in the permit conditions,
- monitoring wells of the SCK monitoring network (Belgian Nuclear Research Center),
- measurement data from the VLM (Vlaamse Land Maatschappij),
- monitoring in areas where interventions are planned and/or carried out (e.g. TGV)
- monitoring networks are created as a result of the preparation of environmental impact reports (EIA),
- monitoring wells of the AWZ (Waterways and Marine Affairs Administration),
- level measurements from BGD (The Belgian Geological Service),
- data from the OVAM (around landfills, around contaminated sites, etc.),
- monitoring in the context of strict scientific research
- monitoring network to monitor salinization in the coastal area,
- etc.

For more details (number, frequency, parameters, etc.) about these monitoring networks, each manager must be contacted separately.

2.1.3 Sediment

2.1.3.1 <u>VMM - Sediment monitoring network – continuous monitoring</u>

The sediment monitoring network consists of approx. 300 points where sediment is analysed. The points are sampled over a period of 6 years. Since 2000, 4 cycles have been completed. The following analyses are performed:

- Triad quality

- MO, PAH, ZM, OCP (DDTs, drins, hexachlorhexanes, hexachlorobutadiene, hexachlorobenzene and chlordanes), PCB
- Assessment of use as soil is incorporated in the geo portal
- The analysis results from this monitoring network were also processed in the sediment explorer (see Section 2.1.3.2)

Based on the answer to a parliamentary question from 2007, it appears that since 2005 a limited screening of brominated flame retardants has also been carried out within the sediment monitoring network. In 2006 this was extended to all (then 150) monitoring points of the monitoring network.

This screening showed that some BFRs were found in a very high number of sediments. Decabromodiphenyl ether (BDE 209) was even detected in more than 4 out of 5 of the samples A maximum concentration of 3000 µg/kg dry matter was determined for BDE 209, for tetrabromobisphenol-A (TBBP-A) up to 42 µg/kg dw. The latter flame retardant was detected in a fifth of the samples. This database is supplemented annually with new results

2.1.3.2 Sediment explorer

The sediment explorer contains information about the quality of the sediment and is based on the Flanders spatial model developed by the VITO. The purpose of the explorer is, on the one hand, to share data about the sediment that is now stored per manager. On the other hand, the goal is to make a prioritization of the sediments to be remediated.

The sediment explorer uses data that is already available about the sediment. The sediment explorer divides waterwaywaterway segments into classes based on several factors:
- Analyses of the sediment: physico-chemical quality
- Location in the water extraction area, size of the waterwaywaterway, structure, MMIF index, fish index, land use, etc.
- Location of the waterwaywaterway: Upstream segments should be addressed for downstream segments.

The different factors are given a weighting factor. The physico-chemical quality is the most important. A score is only awarded for points where analysis results are available.
Important notes:
- The analysis parameters that are taken into account are based on a list of parameters prepared by the UA. The selection of the parameters can affect the result. The more parameters that are measured, the more exceedances there can be.
- The score of a monitoring point is extrapolated to 2.5 km downstream, if no other monitoring points are closer and there are no important confluences and suchlike.
- The physico-chemical analysis results mainly come from the VMM (see, amongst others, the sediment monitoring network) and the province of Antwerp.
- Consultations with other waterwaywaterway managers are being started to see if more data can be shared.

2.1.3.3 Brominated flame retardants – one-off measurement campaign

Within the context of an international study commissioned by the 'Bromine Science and environmental Forum (BSEF)' and coordinated by the Netherlands Institute for Fisheries Research, BFR concentrations in both the sediment and in biota (eel) were also measured at a number of common monitoring points in Flanders.

In 2001, sediment samples were taken at 16 measurement points in the Scheldt basin and at 3 reference sites. These samples were analysed for brominated flame retardants (54), (72):

- HBCD: fluctuated between 8.1 and 7 200 µg/kg O.C. (organic carbon). The highest values were found in the Scheldt at Oudenaarde (7,200 µg/kg OC), the Leie at St.-Martens-Leerne (5,400 µg/kg OC) and the Scheldt at the Dutch border (2,500 µg/kg OC)).
- TBBP-A: In sediment, fairly high TBBP-A concentrations were also measured in the Scheldt in Oudenaarde (670 µg/kg O.C.) and in Beveren, Vrasenedok (890 µg/kg O.C.).
- PBDE: 16 measured congeners, summed. In the Warmbeek, Moervaart, Durme, Nete and Dender, the measured concentrations are low (< 500 µg/kg O.C.), while the measurement locations on the Leie and Scheldt are high (between 5,000 and 41,000 µg/kg O.C.).

The data from this study cannot be freely downloaded. The results for sediment may be available in the water quality counter of the VMM, if the correct measuring point is known. This was a one-off study; the data are not being updated.

2.2 INDIRECT MEASUREMENT DATA OR DIRECT INTERNATIONAL DATA

2.2.1 Soil

2.2.1.1 OVAM - Metal industry in the Kempen region - one-off studies

Many studies have been carried out in connection with the problem of heavy metals in the Kempen region. The BeNeKempen project attempted to bundle all known data. To this end, 5 working groups were established:

- The **Zinc ash work group** is looking for solutions for the presence of zinc ash in the soil.
- The **Water work group** examines the contamination of sediment, groundwater and surface water.
- The **Agriculture work group** provides farmers with cultivation advice, studies how additives improve the soil and starts concrete pilot projects on the cultivation of non-consumer crops.
- The **Nature work group** is investigating how nature managers best deal with the contamination in their domain.
- The **Risk Assessment work group** supports the other working groups and is working on the same methodology for Flanders and the Netherlands. The working group monitors the current bio-monitoring campaigns and coordinates the additional environmental measurements.

The final report of the BeNeKempen (73) zinc ash working group included a map showing the available information about the presence of zinc ash roads.

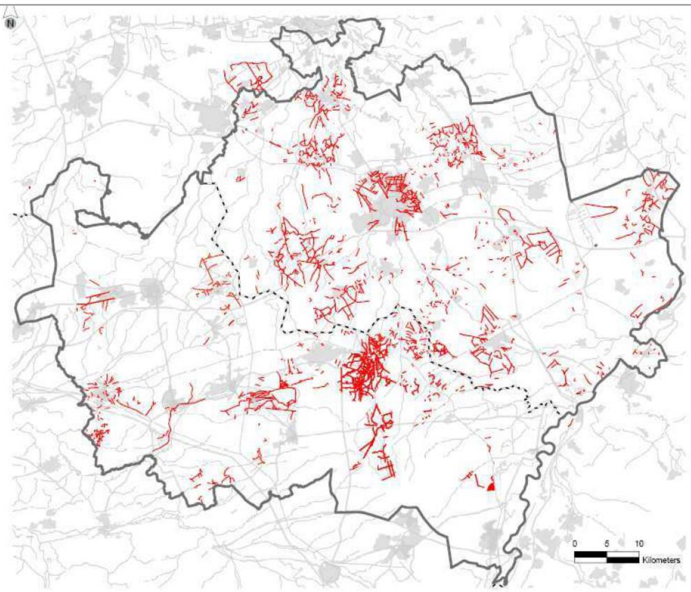


Figure 2-1 Inventory of zinc ash roads (73)

An inventory phase was started at the beginning of the BeNeKempen project. The aim was to collect, evaluate and structure all existing information about the state of the land and water system in the project area and to detect gaps in the information. All available studies and datasets were brought together in a meta database. Data sheets indicate which body manages the knowledge or data from studies, what their quality is and whether there are any knowledge gaps. This meta database gave an overview of the characteristics of the knowledge and datasets: the title of the study or the dataset, the author, the source holder, the owner, the availability, the location, the number of samples, the metals, the compartments, the processes, age, etc. The evaluation resulted in lists of the most relevant reports. The data could be consulted with an interactive bibliographic system that can be consulted via the internet (www.benekempen.eu) and a corresponding map atlas with cross-border maps of the contamination and supporting map layers (74). However, this database is no longer active. The summary reports of the various work groups can still be consulted on the OVAM website. The data is not updated.

In 2008, a study was commissioned by the OVAM into the effect of the diffuse enrichments of metals on earth moving in the Noorderkempen region (17). It listed the following data sources:

- Area coverage maps for Cd, Zn, Pb and As within a 9 km zone around the Balen and Overpelt sites
- Area coverage maps (9 km zone) for Cd around the Olen site
- Area-covering maps (4 km zone) for Cd and Pb around the Beerse site
- Flood zones of the Grote Laak
- Flood zones of the Winterbeek

These maps were drawn up based on the following studies:

- Geostatistical processing of soil analysis data specifically around the 4 sites of the Non-ferrous industry Umicore NV in the Flemish region Ghent University, RO-04-003
- Environmental soil study for 4 (75) Umicore sites in Hoboken, Olen, Balen and Overpelt, Haskoning, September 2003
- Mapping of Cadmium concentrations in the top layer of the Valley Soils and Banks of Winterbeek, Haskoning, January 2008
- Environmental study Metallo in Beerse, TAUW, September 2007

In this study, zones were delineated on the basis of technical reports where concentrations above the free reuse values for Cd, Zn, Pb and As were found. This resulted in an estimated 54 million m³ of land within the 9 km zones. Cd often turned out to be the determining parameter (17).

An additional study (75) was carried out in 2010, examining all technical reports from June 2008 to May 2010 from the six core municipalities of the region. Just as in the first study, this showed that there was hardly any difference between this region and the rest of Flanders regarding the volume of land to be excavated where the value for free reuse was exceeded.

When the reason why a soil could not be reused freely was looked at in more detail, there appeared to be an influence from diffuse contamination. 72% of the volume that does not qualify for reuse is attributed exclusively to diffuse contamination. The diffuse enrichment was determined from 0.1 to 3.9 m below ground level. The number of cases where this enrichment was still determined at a depth of about 2.5 to 3.9 m bgl was limited. In that case, only the zinc parameter above the free use value was measured and for relatively low concentrations (< 120 mg/kg dw). On average, the diffuse enrichment was determined to a depth of 0.85 m. Diffuse enrichment was observed in 50% (median) to a depth of 0.55 m below ground level. The diffuse contamination occurred both in unpaved areas and under a pavement;

This was a one-off study; the data are not being updated.

	Concentratie (mg/kg DS)							
	As	Cd	Cr	Cu	Hg	Pb	Ni	Zn
Gemiddelde	61	4,5	95	134	8,4	227	61,8	298
Mediaan	36	2,9	120	78	8,1	180	61,8	240

Figure 2-2: Average and median of the concentrations above the value for free use and classified as diffuse enrichment (Source: (75))

2.2.1.2 OVAM - Background value maps of heavy metals - one-off study

Commissioned by the OVAM, the University of Ghent(for soil) (76) and Soresma (for groundwater) (77) made a geostatistical analysis and mapping of the heavy metals in the soils of Flanders on the basis of OVAM soil data in 2006 . The irregular distribution in time and space of the OVAM data was converted into a regular data grid (point distance 500 m) by means of a geostatistical approach.

For soil, only measurements whose average depth was within the top 50 cm of the soil and the upper limit of sampling was no deeper than 20 cm; local extremes, unusually high or low values were localized compared to the values in the environment. In certain cases, these measurements were removed from the data set to avoid instability in the calculation.

Based on these data, background value maps were prepared for arsenic, cadmium, chromium copper, mercury, lead, nickel and zinc in soil and groundwater. Background concentration is defined here as the continuous background level of an element consisting of the original metal concentration in the parent material and the diffuse source of contamination in the soil. This was a one-off study; the data are not being updated.

Due to the dynamics in the soil and anthropogenic influences, it is difficult to find the real, natural background concentrations. Natural and anthropogenic depositions occurred through air and water, causing diffuse contamination while losses occurred from percolation and/or biological or chemical decomposition or from the formation of complexes. However, it is possible to estimate the concentration range of the background level. This background concentration thus refers to the concentration range that is generally found in the majority of the study area. This means that it is not necessarily the "natural" (geochemical) background level (76). (77)

2.2.1.3 Soil and eggs - one-off studies

- OVAM study: In the period August-September 2010, levels of dioxins and PCBs in the soil of gardens, vegetables, eggs and in deposition samples were measured in gardens of 16 private individuals, spread across Flanders and in the absence of specific sources. This showed that the concentrations of dioxins and PCBs in eggs from private individuals are significantly higher than in eggs from the commercial circuit. The levels in eggs were clearly related to the levels in the soil. The levels in eggs are adversely affected by a number of factors related to combustion processes: burning material in the garden (own or neighbours), and using a stove, fireplace or multi-burner in cold periods. The stronger the growth in the run, the lower the levels in eggs. Moving weeds to the coop seems to lead to higher concentrations in the eggs, while moving grass clippings to the coop seems to lead to lower concentrations (confidential study).

- The CONTEGG study: In 2006-2007, 59 individuals spread across Belgium measured trace elements and contaminants in free-range chicken eggs and in the soil of the run. This concerned the parameters Dioxins, PCBs, PAHs, pesticides, brominated flame retardants, PFOS and PFOA, mycotoxins and metals. 10 soil samples were analysed each time in the spring and 10 in the autumn. The report can be consulted at https://docplayer.nl/21665525-Contaminatie-van-eieren-afkomstig-van-kippen-gehouden-bij-particulieren.html or in the library of Ghent University. (78)
    - Some of the analysed eggs showed violations of the standards for dioxins and dioxin-like PCBs, for marker PCBs, for the pesticide DDT and also for the metals lead and mercury. The dioxin levels ranged from 1.5 to 95.4 pg TEQ per g fat. Compared to the prevailing standard of 6 pg TEQ per g fat for dioxins and dioxin-like PCBs, this means a non-negligible exceedance in most cases.
    - Brominated and fluorinated compounds, as well as PAHs and other common pesticides (with the exception of DDT) were not or hardly found.
    - The DDT levels were much too high for some of the samples; however, it should be added that the exceedances occurred in only 10% of the cases.

- Egg study in Menen: see human biomonitoring 15 private individuals in Menen, Wevelgem and Wervik (Menen with known contamination problems for these substances); sampling in 2013, 14 data points for dioxins, dioxin-like PCBs and marker PCBs. This was a one-off study, the data are not being updated.

- Gistel study: 2 private individuals in Gistel near a scrap processor; sampling in 2006, 2 data points for dioxins, dioxin-like PCBs and marker PCBs. This was a one-off study; the data are not being updated.

- Report "Proposal for target values - dioxins, furans and dioxin-like PCBs" (VITO 2011): analysis of 20 soil samples (0-20 cm bgl) for dioxins, furans and dioxin-like PCBs. The data points were spread across Flanders; given the aim was to determine target values, locations in areas without sources were chosen. (confidential study). This was a one-off study; the data are not being updated.

2.2.1.4 Environment and health - Healthy from your own soil ("gezond uit eigen grond" - continuous monitoring

A guideline is available on the Flemish Center of Expertise on Environment and Health's "gezond uit eigen grond" ("healthy from your own soil") website for checking whether the soil in your garden is suitable for growing vegetables and keeping chickens. It focuses on diffuse contamination sources (such as stoves, traffic, etc.) to indicate a possible impact on vegetable gardens. It also explains how you can send a soil sample from your garden to a lab for analysis.

The following analysis packages are offered on the website:

- Package 1 - vegetable garden: heavy metals and benzo(a)pyrene (according to CMA)
- Package 2: mineral oil (according to CMA)
- Package 3 – chicken coop: PCDD/F (LOQ upper bound detection limit: 3 ng/kg dw) and dioxin-like PCBs (detection limit LOQ upper bound: 2 ng/kg dw)

The website also offers the possibility to enter the analysis results. Based on the results, tailor-made advice is then provided.

At the end of June 2019, results were already known through this route from 519 locations in Flanders. The locations are known down to municipality level. No address data or XY coordinates are available. These data are not inventoried, there is no reporting obligation. There is also no standardized or spatial approach. The data are continuously updated with new results.

Contact: environment department - Environment and health team

2.2.1.5 Geochemical Atlas of Europe - one-off measurement campaign

The datasets of the geochemical atlas of Europe (79) were created by the sub-organizations of the 'Forum of the European Geological Surveys (FOREGS) Geochemical Baseline Mapping program', and are published by the Geological Survey of Finland.

The IUGS/IAGC Global Geochemical Baselines program aims to establish a global geochemical reference baseline for > 60 determinants in a range of media for environmental and other applications. The European contribution to the program has been implemented by government agencies from 26 countries under the direction of the Forum for European Geological Surveys (FOREGS). The main objectives of this European study were:

- application of standardized sampling methods, chemical analysis and data management to prepare a geochemical baseline across Europe; and
- to use this reference network to align national baseline data series.

Samples of surface water, sediments and three types of soil (organic top layer (humus), mineral top layers (0-25 cm), subsoil (0.5-2.0 m bgl)) were collected at 900 stations, each covering a catchment area of 100 km^2, which corresponds to a sampling density of approximately one sample per 4,700 km^2. In addition, the top 25 cm of floodplains were sampled in 790 areas, each representing a 1,000 km^2 basin. This was a one-off study; the data are not being updated.

Based on this, maps were created per with a grid of 6 km x 6 km. The maps can be freely downloaded from this website: http://weppi.gtk.fi/publ/foregsatlas/ForegsData.php

The JRC (33) reports that this data was used to model the distribution of 8 heavy metals in the top layers of the soil in Europe. A correlation was found between levels of nickel and chromium and the magnitude of earthquakes in certain areas. Cadmium, copper, mercury, lead and zinc are mainly found in central Europe and are related to agriculture and limestone. The use of fertilizers, manure and agrochemicals is also cited here as an explanation. These parameters are also inversely correlated with the distance to roads.

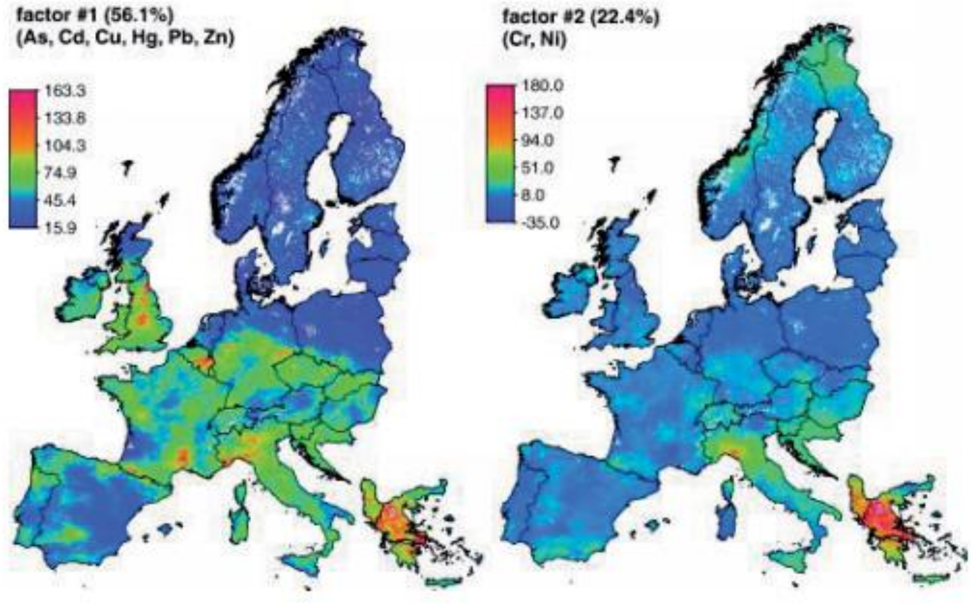
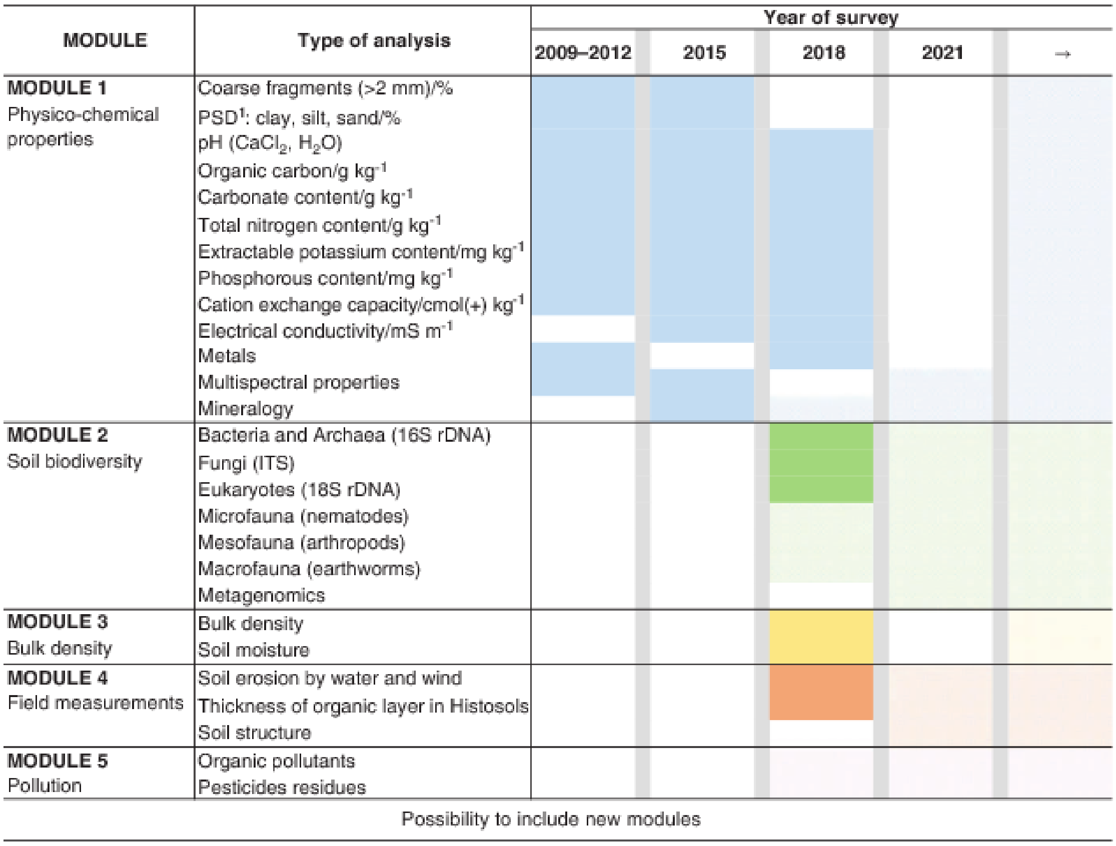


Figure 2-3: heavy metal content in European soils (33)

2.2.1.6 ESDAC LUCAS topsoil survey -JRC - triannual measurement campaign

In 2009, the European Commission extended the periodic 'Land Use/Land Cover Area Frame Survey (LUCAS)' to analyse key features in the top soil layer of 23 EU Member States. The analysis was carried out in one lab, making it the first attempt to create a consistent spatial database of soils across the EU. The final database contains 19,967 samples from 25 countries. 71 samples came from Belgium. The samples were analysed for the percentage of coarse particles, particle size distribution (% clay, loam and sand), pH (in Cacl2 and H2O), organic carbon (g/kg), carbonate content (g/kg), phosphorus content (mg/kg), total nitrogen content (g/kg), extractable potassium (mg/kg), Cation exchange capacity (cmol(+)/kg) and multispectral properties. Heavy metals (As, Cd, Cr, Cu, Hg, Pb, Mn, Sb, Co and Ni) were also analysed. Based on this, maps were created with concentrations of these metals in the top layer (0-20 cm bgl) of European soils. The maps have a resolution of 1 km and are freely available. The measurement results for heavy metals for each individual point are not publicly accessible (80). New sampling and analysis campaigns followed in 2015 (22,000 samples from 29 countries), 2018 (the same number of samples as 2015) and are planned in 2021. Heavy metals were re-analysed in 2018. The results from these analysisare not yet available. The possibility of also analysing organic contaminants and pesticides in the samples from 2018 and 2021 is still being explored. (81)



PSD[1], particle-size distribution.

Figure 2-4: Different modules form the overall structure of the survey; each module corresponds to different types of analyses. The analyses are repeated at a standard time interval, namely every 3 years. Types of analysis already established (full colour cells) for the campaign scheduled for 2018. Possible analyses for 2021 (dotted cells) are still under discussion and there will be the opportunity to implement the survey further by including new modules (81)

2.2.1.7 Study of exposure of residents to pesticides in the Netherlands - one-off measurement campaign

A study from the Netherlands (starting 2015) (82) conducted a study into the exposure of people who lived within 250 m of a field where flower bulbs were grown to pesticides. 46 different pesticides were analysed. Higher concentrations were found in the environmental samples of people living close to the affected fields compared to a control group. Even higher concentrations were found in and around the homes of the persons who cultivated the flower bulbs. Biomarkers for 2 of the 5 pesticides examined were found in urine samples, including in young children. The concentration of the biomarkers was correlated with the concentrations found in and around the home. The following measurements were taken: outside air, house dust, soil from the gardens and vegetables and fruit from the gardens and urine samples from the inhabitants, “hand wipe samples”. In addition, spray drift field measurements were performed to estimate deposition downwind from the field.

A total of 124 top samples from the soil were analysed. Enough samples where the detection limit was exceeded to allow further data analysis were available for 7 pesticides. For 3 of these 7 pesticides, significantly higher concentrations (5 to 10 times) were found in the soil samples compared to the control group, further away from the fields. The higher concentrations in soils may contribute to higher concentrations in house dust because soil particles are brought in.

Analysis technique soil samples: LC-MS/MS
The study can be freely downloaded:
https://www.bestrijdingsmiddelen-omwonenden.nl/blootstellingsonderzoek

The individual analysis results are not included in the report.

2.2.2 Water

Via the VMM geo portal water quality you can consult and download data from various monitoring networks:

2.2.2.1 Surface water monitoring network - continuous monitoring

The VMM's surface water monitoring network currently contains about 1,500 measurement points. This monitoring network contains the following information:

- BBI (Belgian biotic index) /
- MMIF (multimetric macroinvertebrates index Flanders),
- PIO (prati index - oxygen index quality class)
- Manure action plan (nitrate evolutions,
- bacteriology
- phytobenthos
- phytoplankton

In addition, a large number of physicochemical analysis results are also available. The database of the surface water monitoring network dates back to 1989. The number of measuring points, location, analysed parameters, analysis techniques, etc. has steadily evolved over the years. Each year, depending on various aspects (current projects, specific questions, reporting obligations, budgets, etc.), it is determined which parameters will be analysed at which point and at what frequency. Analysed substances include

- T, pH, O_2, Cl, BOD, COD, KjN, NH_4, NO_3, NO_2, Nt, Pt, oPO_4, Suspended matter, heavy metals
- some 400 organic parameters, including: Phenols and Chlorophenols, Bisphenol-A, Nonylphenol, Phthalates, Hormones, 30 medicines (no longer analysed in recent years), Organochlorine pesticides, Organophosphorus pesticides, Organo nitrogen pesticides, Organotin pesticides, Metals, PAH, PCBs, PFOS, Brominated flame retardants, Herbicides, Volatile organic compounds, chlorobenzenes), hydrocarbons

The results of the monitoring network are processed to determine the quality of the Flemish surface waters. This quality is reported annually by the VMM. For example, a check is made for each Flemish body of water as to whether the environmental quality standard is exceeded.

The dataset is very extensive. The data for each measuring point can be consulted via the VMM geo portal. When a specific question is asked (e.g. concerning a certain parameter, area or period), data can also be supplied in bulk on request.

2.2.2.2 Waste water monitoring network – continuous addition of data

The waste water monitoring network contains an extract from the active, discharging measuring wells of the waste water monitoring network. Specifically, this data set shows the measuring points where the wastewater leaves the company at that time and the associated analysis results that are available. The monitoring network contains data since 1990. The waste water monitoring network is demand-driven. The questions from internal and external customers are tested against the feasibility based on the means, the analysis capacity of the VMM laboratory and the external laboratories that carry out analyses on behalf of the VMM. In the VMM water database, this data is managed and supplemented with the results of concentration measurements from business campaigns and with the flow data that companies report on a voluntary basis. These data are publicly accessible via the VMM geo portal.

The most important projects are the control of company discharges for the levy and collection of the remediation contribution, the implementation of the (self) control program of WWTPs and the study of new and unknown contaminants to substantiate the policy.

The basic parameters that are systematically investigated are Biochemical oxygen demand, Chemical oxygen demand, Nitrogen (total), Phosphorus (total) and heavy metals. In addition, additional analyses are carried out on various substances in the context of specific questions. This database is very extensive and contains thousands of results for each year. The data for each measuring point can be consulted via the VMM geo portal, but cannot be downloaded in its entirety. On demand, the VMM can supply certain data in bulk if a specific request is submitted.

2.2.2.3 VMM: Pesticides in water - one-off analysis of the data, but continuous monitoring

The VMM published a study examining the available data concerning pesticides in water. Data was used from analyses at WWTPs, at companies, in surface water and in perch and eel (39). The study is free to download. The data can be consulted in the water quality portal if the measuring point is known. The VMM must be contacted to request data in bulk.

- In WWTPs
- In the period 2015-2016, the VMM carried out measurements of 86 pesticides on effluents from 16 WWTPs spread across Flanders. The WWTPs are chosen in such a way that they are representative of Flanders in terms of location, size and type. A similar campaign was carried out in the period 2010-2014. In the same period, the VMM carried out analyses of 57 pesticides on influents and effluents from 8 WWTPs from Haspengouw. The percentages of recovery of the WWTP effluents for the 30 most commonly encountered pesticides in Haspengouw are almost always higher than in the rest of Flanders. (39)

- **At Companies**
  In the period 2012-2016, measurements were performed for various projects of a total of 115 pesticides in the discharged waste water from a total of 72 companies. Since the measurements were taken for different projects, not all 115 pesticides were analysed at all 72 companies. One or more of a total of 62 pesticides found were found at 42 companies.
  - Companies that are licensed for discharging pesticides into waste water: Out of 42 companies, only 6 are licensed to discharge a total of 9 of the tested pesticides. When the 178 individual results of analyses on samples taken during the normal operation of those 6 companies (i.e. excluding results from incidental discharges) are tested against the maximum discharge standards of the permits, we find 3 exceedances at 2 different companies in the chemical sector. Those 3 exceedances or 1.7% exceedances on 178 measurements show that there is no systematic problem with the licensed companies. (39)

- Unlicensed companies: Out of a total of 6471 measurements on all 31 pesticides, there are only 59 or 0.9% exceedances of the classification criterion GS. In addition, most exceedances are limited in size: only 18 measurements or 0.3% exceed the classification criterion by a factor of 10 or more. These figures indicate that there is no systematic problem with non-licensed companies. (39)

– **In surface water**
  The VMM has been systematically analysing pesticides in surface water for 20 years. The number of measured substances grew to 112 in 2016. The pesticide monitoring network consisted of about 40 monitoring points in 1996, but has expanded considerably since 1998 to about 125 locations in 2016. As in previous years, the 2016 measurement results show that a large number of the 112 detected pesticides are not or rarely found in surface water:
  - 26 pesticides are not found anywhere;
  - 30 pesticides are found in 0 to 5% of the measurement locations.

  On the other hand, there are also substances that are found very frequently. The following substances are found in 75 to 98.5% of the measurement locations: 2-hydroxy-atrazine, AMPA, glyphosate, diuron, terbuthylazine, dimethenamid, metalochlor, (4-Chloromethylphenoxy) acetic acid, linuron, diflufenican, dimethomorph and imidacloprid.

  Substances often detected (50 to 75% of the measurement points) are carbendazim, isoproturon, metamitron, chloridazin, ethofumesate, flufenacet, desethylterbutylazine, pirimicarb, fluroxypyr, chlorotoluron, bentazone, simazine, mecoprop, metazachlor, 2,4-dichlorophenoxyacetic acid and metobromuron.

  The average concentrations of prohibited substances are decreasing. This applies for, among other things, atrazine, diuron, endosulfan, monolinuron and simazine. Some of these substances are still found at many measurement locations, but the average concentration has decreased over the years. For a number of prohibited substances such as DDT, dichlorvos and propachlor, however, there has been a slight increase in the concentrations found in recent years. (39)

  - **Pesticides in surface water intended for the production of drinking water**
    The water companies have an operational monitoring obligation, which is aligned with their risk evaluation and risk management strategy. In their implementation, they monitor the surface water used for the production of drinking water.

    The VMM pesticide measurements and the companies' drinking water were viewed side by side in a study. Both monitoring networks have a different finality and supplement each other. According to the drinking water decree, only those pesticides that are likely to occur in the water have to be measured. So, this is an area-specific approach.

    To monitor the status of the surface water at the intake points, 10 existing VMM measurement locations were selected. These locations are always near the collection points of the drinking water companies. The VMM samples each location at least four times a year. In addition, as part of their operational monitoring, the drinking water companies monitor the surface water intended for the production of drinking water more frequently. The VMM analysed the samples for the same 112 pesticides as for the other measurement locations. (39)

2.2.2.4 Brominated flame retardants in wastewater - one-off measurement campaign

In 2005, the environmental inspectorate sampled and analysed various waste waters from textile companies, plastic producers and waste water processors for PBDEs and HBCD. The determinations of these substances in wastewater were carried out by the VITO. Sampling was carried out during two campaigns in 2005 and it was found each time that several companies discharged one or more of the substances concerned in concentrations higher than 10 pg/L of unfiltered waste water (6 of the 29 sampled companies during the first campaign and 8 out of 30 during the second campaign);
In effluent water samples from textile companies, concentrations up to 363 pg/L for BDE-209 and 480 pg/L for HBCD were measured. No other PBDEs were detected besides BDE 209. These results can be considered to be concentrations in water with suspended matter. Detection limits were < 0.3 pg/L for BDE 209, < 0.02 pg/L for other PBDE congeners and < 1 pg/L for HBCD (500 ml sampling). (54)

Tabel 3: Aantal stalen geanalyseerd voor BDE 209 en HBCD.

	BDE 209	HBCD
Concentratie in µg/L	Aantal resultaten	Aantal resultaten
< 1	39	51
1 - 10	6	3
10 - 100	10	2
> 100	4	3

Figure 2-5: number of samples analysed for BDE 209 and HBCD content (54)

In the spring of 2006, a new monitoring campaign was conducted in which 39 waste water samples were analysed. BDE 209 was found in 26 samples with a maximum concentration of 100 pg/L. Decabromodiphenyl ethane was found in 11 samples. In addition, 20 samples of TBBPA were analysed. However, this component remained below the detection limit of 1 pg/L in all samples. In the autumn of 2006, 36 samples were selected and BDE 209 was found in 25 of those samples. In one sample there was even a concentration of 4,700 pg/l. In two other samples, up to 100 and 190 pg/l of BDE 209 was detected, respectively.

2.2.2.5 Response project: Reactive transport modelling of point source contamination in soils and groundwater - one-off study

A BELSPO study into the transport of contaminants in soil and groundwater is under way from 2016-2021. Within the context of this study, groundwater at 8 cemeteries (3 in Flanders) and 7 former municipal landfills (4 in Flanders) was screened. The results of this study have not yet been published. However, the following information is already available:

BAM (a decomposition product of dichlobenil) was found in concentrations above the standard at 4 cemeteries, 2 of which in Flanders. The concentrations found were max. 0.15 and 0.27 µg/L. Other herbicides (bromacil, metazachlor, MCPP, etc.) were also found above the standard. The total of pesticides in the monitoring wells in these cemeteries ranged from 0.9 to 4.5 µg/L. Soil samples were also analysed at the cemeteries where BAM was found. Dichlobenil was found in these, suggesting that this herbicide is effectively the source of the increased BAM concentrations in groundwater.

At the landfills, mainly lead and arsenic above the standard were found in the groundwater.

It should be noted here that the samples were not taken and analysed by an accredited lab. The analysis results from this will not be published. To consult these, permission is required from the owners of the sites concerned.

2.2.3 Biota

Various studies and monitoring networks monitor the presence of certain parameters in biota. In this section we list the data available for animals, mainly in surface water and sediment. Human biomonitoring will be discussed in a later section. The results of these biota studies are relevant because they provide information about the presence of contaminants in surface water and sediment. In the event of flooding and dredging, these contaminants can spread to the land. If higher concentrations occur at certain locations than in other areas, a link may also be established between certain land uses or activities in these locations and a higher level of diffuse contamination.

2.2.3.1 VMM/INBO: Biota Monitoring Network – 2015-2022 – continuous monitoring

A European directive obliges the member states to monitor biota (or sediment):

1. An assessment must be made against the environmental quality standard for 11 substances for which an environmental quality standard for biota (and/or sediment with the same level of protection) is applied.
2. A long-term trend analysis should be performed for substances that tend to accumulate in biota and/or sediment (special attention to 20 substances, including those for which a biota environmental quality standard has been established).

In Flanders, the following measurement strategies have been drawn up for this:

1) Measurement strategy for environmental quality standard testing for substances with biota EQS:

- **Objective:** Standard test against the biota environmental quality standard to protect top predators from secondary poisoning.
- **Matrix**: biota.
- **Contaminants:** Hexachlorobenzene, hexachlorobutadiene, methyl mercury, PBDEs, fluoranthene, benzo(a)pyrene, PFOS, HBCDD, dicofol, heptachlor (epoxide) and dioxins.

From 2015, a 4-year cycle 2015-2018 of 44 measuring points was started, in which 11 different measuring points are measured each year. After an initial cycle (2015−2018), in which all 44 measurement points are sampled, the same measurement points will be repeated in the second cycle from 2019 (2019−2022). The fish species perch and eel are used as the organism (matrix) for determining accumulated contaminant concentrations. Eel, due to their protected status, are only recommended by EC guidance for the continuation of existing monitoring programs. The large fat percentage of this fish (15% on average) also makes it easy to overestimate the accumulated contaminant concentrations. Based on the previous arguments, VMM prefers perch in the first place, and eel only in the second place in the absence of sufficient perch.

The analysis of the PAHs fluoranthene and benzo(a)pyrene should be done in crustaceans or molluscs. Since it is often difficult to obtain the required biomass for these taxonomies, active biomonitoring is used by means of the triangular mussel. Contaminant analysis is done here on mixed samples based on the entire organism.

2) Measurement strategy for the analysis of long-term trends for bioaccumulative substances

- **Objective:** Analysis of long-term trends in priority substances that tend to accumulate in sediment and/or biota.

- **Matrix:** Most substances are measured in sediment since many of the requested substances have been measured by the VMM for some time as part of the routine sediment monitoring network. Dicofol, PFOS and dioxins are currently not analysed in sediment, but will be measured from 2015 in the context of testing against biota EQS. Therefore, biota monitoring for these substances is used for the trend analysis.
- **Contaminants:** Hexachlorobenzene, Hexachlorobutadiene, Methylmercury, PBDEs, Fluoranthene, Benzo(a)pyrene, PFOS, HBCDD, Dicofol, Heptachlor and Heptachloro epoxide, Dioxins, Anthracene, Cd, Pb, C10 – C13 Chloroalkanes, DEHP, Hexachlorocylphenyl, Pentachlorobenzophenoxyphenol.
- **Measurement frequency:** 11 measuring points that are also sampled in the context of biota monitoring for environmental quality standard testing. 3-yearly measurement frequency. 3 to 4 measuring points are sampled every year. Dicofol, PFOS and dioxins are an exception to this, as these substances are measured in biota in a four-year cycle (11 measuring points per year).

Table 2-2: VMM biota monitoring overview xxx

		Objective	
		EQS assessment	**Monitoring long-term trends**
Substances with a biota EQS	Hexachlorobenzene	Biota	WB
	Hexachlorobutadiene	Biota	WB
	Hg	Biota	WB
	HBCDD	Biota	WB
	Total PBDE #28-154	Biota	WB
	PFOS	Biota	Biota
	Dicofol	Biota	Biota
	Heptachlor	Biota	WB
	Heptachlor epoxide	Biota	WB
	Dioxins	Biota	Biota
	Fluoranthene	Biota	WB
	Benzo(a)pyrene	Biota	WB
Other bioaccumulative substances	Anthracene	N.A.	WB
	Cd	N.A.	WB
	Pb	N.A.	WB

Biota: The substance is measured in biota (perch and/or eel; fluoranthene and benzo(a)pyrene in triangular mussels), a total of 44 measurement points over a period of 4 years (11 MP/year); WB: The substance is measured in sediment, a total of 11 measuring points over a period of 3 years (3 to 4 MP/year); N.A.: substance is not analysed within the context of the stated objective

The results from 2015 have already been reported (11 measurement locations sampled).

The results show that:
- Exceedances of the biota environmental quality standard were established for HCBz, mercury (Hg), PBDE, HBCD, benzo(a)pyrene, PFOS and dioxins.
- It was striking that for both Hg and PBDE the standard was exceeded at all measuring points, both for perch and for eel. This was also the case for PFOS, with the exception of the eel pool from the Dijle and theperch pool from the Dender. For HCBz, HBCD, PFOS and dioxins, the exceedance was species dependent.
- Finally, higher concentrations (PAHs) were generally observed in triangle mussels than in swan mussels.

- Based on the results of the current study and a comparison with data from the literature, we can state that the current biota environmental quality standard for Hg and PBDE is exceeded in all fish species from Flemish and European waterwaywaterways.

Substances such as mercury, PFOS and PBDE are exceeding the biota standard across Europe, even in pristine systems. This therefore points to a general European problem and indicates that the distribution of these substances is largely via atmospheric deposition. (83) (84)

A field study was already carried out in 2014. (85). In 2014, biota environmental quality standards were already available for only 3 substances (mercury, hexachlorobenzene and hexachlorobutadiene). These three substances were measured in eel and bass muscle tissue at 16 Flemish waterwaywaterways. In addition, trends in bioaccumulation are determined for eels on the basis of historical data from the eel contamination monitoring network of the Institute for Nature and Forest Research (see Section 2.2.3.2).

At two reference sites and three project sites, the following contaminants were determined in eel muscle tissue: Brominated diphenyl ethers (PBDE), Perfluorooctane sulfonic acid and its derivatives (PFOS), Hexabromocyclododecane (HBCDD), Dicofol, Heptachlor and Heptachlor epoxide. The polyaromatic hydrocarbons (PAHs) Fluoranthene and Benzo(a)pyrene were determined in triangular mussel tissue, which are hung at the reference sites for six weeks.

2.2.3.2 VMM /INBO - Eel Contamination Monitoring Network - (monitoring network from 1994 to 2007 or 2009)

In 1994, the INBO started the Flemish Eel Pollutant Monitoring Network commissioned by the Flemish government. The monitoring network consists of a number of fixed points where the eel were caught and the contaminants in it were measured. The project was also in line with the obligations for the European Water Framework Directive. (86)

Between 1994 and 2006, more than 2,940 eels from 365 measurement sites were examined for the presence of (87):

- Heavy metals: cadmium, mercury, lead, chrome, nickel, copper, zinc, arsenic and selenium
- Polychlorinated Biphenyls: PCB 28/PCB 31, PCB 52, PCB 101, PCB 105, PCB 118, PCB138, PCB153, PCB 156, PCB 180
- Hexachlorocyclohexanes: a-HCH, gamma-HCH (Lindane)
- Cyclodienes (drins): Dieldrin, Aldrin, Endrin
- Polychlorobenzene: Hexachlorobenzene (HCB)
- Chloroethanes: p,p'-DDD (TDE), p,p'-DDT, p,p'-DDE, trans-nonachlor

Brominated flame retardants, volatile organic compounds (VOCs), endocrine disruptors, dioxins, PFOS, methallothioneins and polycyclic aromatic components were measured at a selection of measuring points. The results were included in several reports.

The choice of locations to be sampled was based on the list of public (fishing) waters. When choosing the exact locations, an effort was made to align with the sediment monitoring network of the Flemish Environment Agency (VMM).

From 2001, as many waters and locations where information was already available were sampled again in order to obtain a picture in the medium term of a possible evolution of contamination in Flemish public waters.

Reports on the results for the period 1994-2007 state the following relevant conclusions and recommendations:

- The lindane concentrations in the Westhoek make this place an absolute "black spot". The concentrations found here were up to 5 times higher than the highest values reported in the literature. Comparison with Dutch data from the same period shows that our concentrations are even 10 times higher. Since June 2002, the use of lindane in agriculture has also been banned in Belgium.
- The Westhoek and the creek areas emerged as the least contaminated areas with regard to PCBs.
- Many substances, of which the use has been banned in our country for several decades, are still found in our aquatic ecosystems;
- in 76% of the eels analysed and 78% of the sampled locations the Belgian PCB consumption standard for fish (75 ng.g-1 fresh weight) is exceeded.
- some locations contain very high concentrations of brominated flame retardants (see Section 2.1.3.3)

Additional studies:
Given that investments had to be made in a significant number of samples taken from eels, in addition to the priority contaminants to be determined (PCBs, organochloride pesticides and heavy metals), it was decided to carry out a number of additional studies on the sampled material in collaboration with other institutions or universities. Below is an overview of the potentially relevant studies:

- **Study of the usefulness of eel Anguilla anguilla as a monitoring organism for measuring endocrine disruptors in our environment:** Here, the potential effects of xenoestrogens were measured in 142 eel samples from 20 different locations, via determination of the plasma vitellogenin (VTG) content and correlated with the in situ degree of contamination
- **Volatile organic compounds in eels:** Twenty eels from different freshwater types were analysed for 52 volatile organic solvents. The BTEX substances (benzene, toluene, ethylbenzene and xylene) are found in all eels. Chlorobenzene, 1,3-dichlorobenzene, 1,2,4-trichlorobenzene, naphthalene and chloroform are present in 70-90% of the samples. Nine VOCs (1,3,5-trimethylbenzene, isopropylbenzene, tetrachloroethene, 1,2,4trimethylbenzene, 1,2-dichlorobenzene, hexachlorobutadiene, 1,2-dichloroethane, p isopropyltoluene and 1,2,3 trichlorobenzene) are found in 35-60% of the eels.
- **Brominated flame retardants in eel: see Section** 2.1.3.3
- **Screening for dioxin in eels from Flanders using the CALUX assay**

Tabel 3.1: Geanalyseerde stoffen en analyselaboratoria. Voor de gebromeerde vlamvertragers en voor de VOS werden de analyses slechts op een beperkte selectie van meetplaatsen uitgevoerd.

Stofgroep	Stoffen	Analyselabo
Zware metalen:	cadmium, kwik, lood, chroom, nikkel, koper, zink, arseen en selenium	Centrum voor Onderzoek in Diergeneeskunde en Agrochemie (CODA)
Polychloorbifenylen:	PCB 28/PCB 31, PCB 52, PCB 101, PCB 105, PCB 118, PCB138, PCB153, PCB 156, PCB 180	Departement voor Zeevisserij (DVZ) van het Centrum voor Landbouwkundig Onderzoek (CLO)*
Hexachloor-cyclohexanen:	α-HCH, γ-HCH (Lindaan)	DVZ/CLO
Cyclodienen (drins):	Dieldrin, Aldrin, Endrin	DVZ/CLO
Polychloorbenzeen:	Hexachloorbenzeen (HCB)	DVZ/CLO
Chloorethanen:	p,p'-DDD (TDE), p,p'-DDT, p,p'-DDE, trans-nonachloor	DVZ/CLO
Gebromeerde vlamvertragers:	HBCD, TBBP-A, PBDE's	Instituut voor Binnenvisserijonderzoek, Ijmuiden (RIVO)
Vluchtige organische solventen:	50 verschillende stoffen	DVZ/Beheerseenheid Mathematisch Model

* vanaf 1 april 2006 is het Centrum voor Landbouwkundig Onderzoek (CLO) samen met het wetenschappelijk deel van het Centrum voor Landbouweconomie (CLE) ondergebracht in een Intern Verzelfstandigd Agentschap (IVA) zonder rechtspersoonlijkheid onder de benaming 'Instituut voor Landbouw- en Visserijonderzoek (ILVO)'.

Figure 2-6: Tabel (87): analyses of eel contamination monitoring network

2.2.3.3 INBO -V.I.S. – contaminant monitoring network: 1994-2006

The Fish Information System (VIS) is an interactive database in which the INBO collects and makes available as much data as possible about fish, fish stocks, fish contaminants, fish indexes and reintroductions in Flanders.

An overview of contaminants in eel fish meat and some other fish can be downloaded. These are heavy metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn), PCBs (10) and pesticides (aldrin, dieldrin, endrin, pp-DDE, pp-DDT, HCB, HCHA , HCHG, TNONA, TDE)

This overview is available in Word, Excel or PDF and contains 18,337 data points, divided over 29 parameters in the period 1994-2006, divided over 71 municipalities. The XY coordinate of the measuring point is included. Most of the analyses were carried out on eels (1491) and, in addition, a thousand on perch, pike and zander. A smaller number of measurements is available for roach, bream, carp, rudd, ide, sea bass and tench.

The data from the eel pollutant monitoring network is probably also partly included in this database. However, there are no results for brominated flame retardants, for example. The project-based results of the eel contaminant monitoring network may not be included in the V.I.S. database.

The concentrations are expressed in ng/g fresh weight. https://vis.inbo.be/--

2.2.3.4 Brominated flame retardants - one-off measurement campaign

2.2.3.4.1 Scheldt basin - eel

In 2000, as part of the same study as the sampling of sediment (see Section 2.1.3.3), eels were sampled at 18 measurement locations (15 in the Scheldt basin and 3 reference sites) and analysed for HBCD, TBBP-A and PBDEs

- HBCD: The measured concentrations varied widely, from < 1.7 to 33,000 µg/kg fat weight. The highest HBCD concentrations were found in the Scheldt at Oudenaarde (33,000 µg/kg fat weight), the Leie at St.-Martens-Leerne (7,100 µg/kg) and at Oeselgem (4,700 µg/kg) and the Dender in Appels (1,300 µg/kg). For comparison: in the Netherlands, eel from 11 places on river systems were analysed. The measurements ranged from 12 to 850 µg/kg fat weight.
- TBBP-A: The measured concentrations of TBBP-A are usually low
- PBDEs: The levels of PBDEs measured in eels in Flanders are also very different depending on the measurement location. High concentrations were found in the Leie and the Scheldt. Extremely high concentrations were found at one measuring site, namely the Scheldt at Oudenaarde. The total for BDEs was 32,000 µg/kg fat weight. Compared to analysis results for PBDEs in fish from other countries, the concentrations found in the Leie and Scheldt are high to very high, and comparable to values found in contaminated sites abroad. Exceptionally high concentrations as measured in eels from the Scheldt at Oudenaarde were only reported in one carp from Virginia

The high values of certain brominated flame retardants found in sediment and eels
at certain measurement locations in the Scheldt basin, may be related to the presence of a fairly intensive textile industry that is geographically highly concentrated. 95% of the activities are located in West or East Flanders, the main concentrations being the regions around Kortrijk and Ghent.

Studies also showed that sampling is more crucial than usual to obtain representative results. Since PBDEs have seen an enormous increase recently, the deposition of PBDEs in sediments is limited to the top layer (sometimes only the top cm). If the sampling is done by means of a grab sample, this top layer is thinned with the underlying sediment layers, which can lead to an underestimation of the PBDE concentrations in the sediments (54).

2.2.3.4.2 Fish from the Scheldt

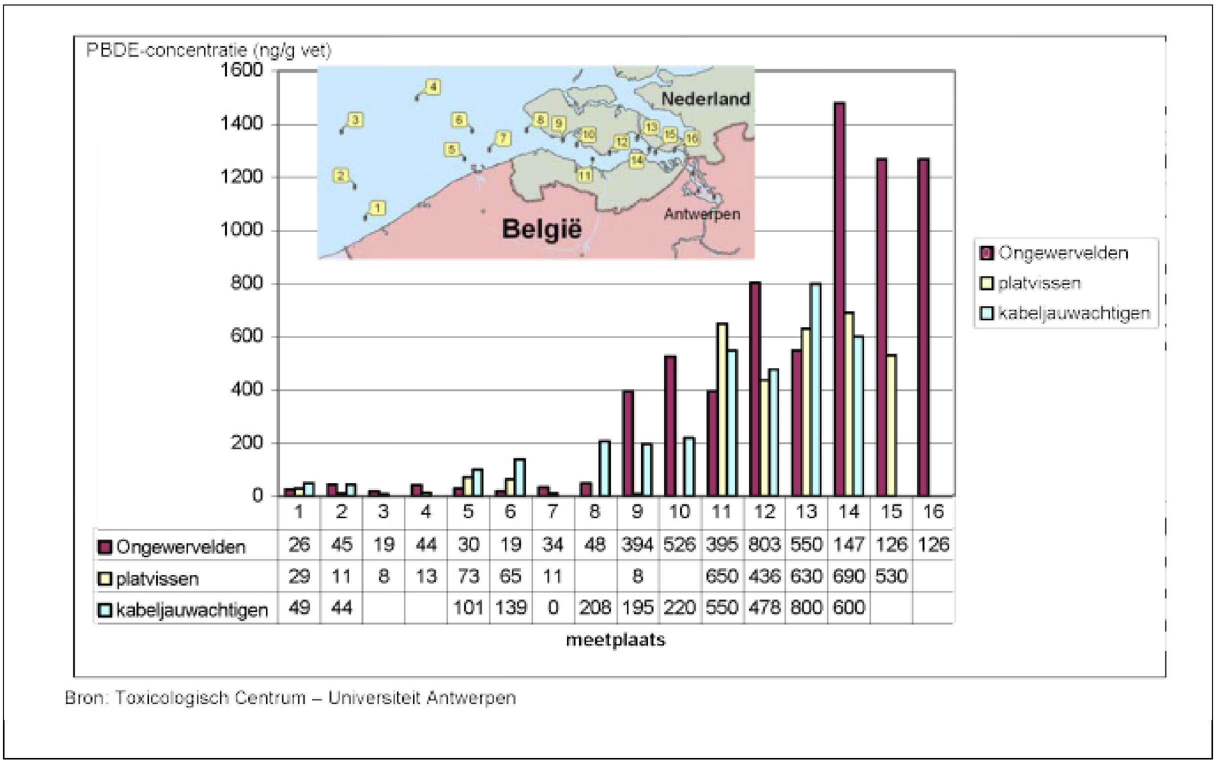
After completing the study described in the above sections, HBCD was also measured in samples from the Scheldt in collaboration with a laboratory of the Norwegian Institute of Public Health. Because HBCD is/was produced on the banks of the Scheldt in Terneuzen, this is an excellent place to search for this contaminant. HBCD was measured in most of the samples examined. (54), (72)

2.2.3.4.3 North Sea and Scheldt

In 2001-2003, a large scale study of biological samples from the North Sea and the Scheldt was carried out. These samples were analysed for PBDEs, PBBs, PCBs and OCPs

In 2001, samples were taken at 16 measurement points in the Belgian North Sea and in the Western Scheldt
from invertebrates (crabs and shrimps), flatfish (sole, dab, plaice) and codfish (pout and whiting). These samples were analysed for 8 polybrominated diphenyl ethers (PBDEs), namely BDE 28, 47, 99, 100, 153, 154, 183 and 209. BDE 183 was never found. The concentrations found varied widely and were also highly location-dependent. However, concentrations in invertebrates and fish were increased in the vicinity of the port of Zeebrugge. It is unclear whether this is due to the port itself or to the influence of the Scheldt plume that stretches to there. However, it was found that the concentrations of PBDEs in the samples taken in the Western Scheldt were significantly higher than those from the North Sea.

In addition, there is not only a location dependence for the measured concentrations between the North Sea and the Scheldt, but there is also a clear link in the Scheldt between the concentration of flame retardants and the distance to Antwerp: the closer to Antwerp, the higher the values measured. This trend is likely to be related to the use of these products further upstream. The PBDE concentrations in the fish in the Scheldt are comparable to values found in heavily contaminated areas. Similar PBDE concentrations were measured in fish in the Great Lakes in North America and in the River Tees in Great Britain. The concentrations in the Scheldt can thus be catalogued as very high, placing the Scheldt among the top locations in terms of contamination with PBDEs. (54), (72)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ongewervelden	26	45	19	44	30	19	34	48	394	526	395	803	550	147	126	126
platvissen	29	11	8	13	73	65	11		8		650	436	630	690	530	
kabeljauwachtigen	49	44			101	139	0	208	195	220	550	478	800	600		

Figure 2-7: PBDE content (ng/g fat) (54), (72)

2.2.3.4.4 In terrestrial biota

Data on PBDEs in terrestrial animals is very scarce. Most available data are from top predators, such as birds of prey. (54), (72)

- In one study, mice (70 samples) and songbirds (tits - 40 samples) were examined for PBDEs. The animals were collected in the green belt around Antwerp. Of these animals, either liver and muscle were examined (mice), or eggs and body fat. The availability of such samples is limited, hence the inhomogeneous sampling. Various PBDE congeners were determined in these samples.
- In a recent study, the concentrations of PBDEs in and between nests were measured in eggs of great tits (Parus major) - 38 samples
- Recently, sparrow hawks and buzzards, which were collected in Flanders (VOC Opglabbeek), were examined for PBDEs. Different tissues (liver, muscle, fat, brain and serum) were analysed for 8 PBDE congeners. Special attention was paid to BDE 209, the main component of the technical deca-BDE technical mixture, which is currently the only mixture used in Europe .
- In another study, PBDEs were measured in 40 individual eggs of little owls (Athene noctua).
- In another study, liver and muscle samples from aquatic and terrestrial birds of prey of Flanders were analysed for PBDEs.

- A recent study examined different tissues from 33 foxes (muscle, liver and fat) for PBDEs. The foxes were collected in the green belt around Brussels.
- Hedgehog carcasses were collected all over Flanders and Brussels during the period 2002-2003. The hedgehogs collected were mostly ones that died in Vogelbescherming Vlaanderen (Bird Protection Flanders) bird shelters (VOCs Anderlecht, Malderen, Ostend and Opglabbeek) and partly road kill. The hedgehogs came from the provinces of West Flanders, Limburg, Antwerp and from Brussels. Tissues (liver, kidneys, muscle and fat tissue and hair) from 42 hedgehogs were analysed.
- In 2000, 20 samples of belly fat were collected during autopsies in the University Hospital of Antwerp. The same samples were also tested for PCBs and some pesticides, such as p, p-DDE (a metabolite of DDT) and hexachlorobenzene (HCB).
- PBDE congeners 28, 47, 49, 66, 85, 99, 100, 138, 153, 154, 183 and 209 were measured in 11 individual serum samples and 4 pooled umbilical cord serum samples. These were available from other projects that took place between 1999 and 2004 at the Toxicological Center, UA.
- Another study in 2007 investigated the PBDE concentrations in pooled serum samples from 3 age categories, namely new-borns (umbilical cord serum), adolescents and adults from Flanders (Belgium). For this, serum samples from these three age categories and from 8 different Flemish regions were collected. Samples from the same age range and region were pooled In total, 23 pooled serum samples (3 age groups x 8 regions, except 1 sample not available) were analysed for PBDE congeners.

2.2.3.5 Organophosphorus flame retardants – one-off measurement campaign

In 2015, a study was also published regarding the concentrations of organophosphorus flame retardants in eel in Flanders (88). Tissue from 170 eel, caught at 26 locations between 2000 and 2009 across Flanders were analysed. PFRs were found in all mixed samples, indicating that these substances are widespread in the environment. The concentrations found were on average lower than the concentrations of PBDE and HBCD. Concentrations varied between 3.5 and 45 ng/g ww. (88).

The study can be downloaded from https://www.sciencedirect.com/science/article/pii/S001393511500167X (pay site).

2.2.3.6 SOS Mezen – one-off measurement campaign

In September 2019 (89), a report was published by the Velt and Bird Protection Flanders that investigated pesticide residues in dead tit nestlings. In 2018, Velt (Association for Ecological Living and Gardening) and Bird Protection Flanders received many reports from worried citizens about young offspring of great and blue tits that had died in their nest boxes. At that time, the impact of feeding boxwood moths in gardens became increasingly visible, leading to the use of pesticides to specifically address this. Citizens wondered if a link could be made between the two.

In August 2018, the 'Exploratory study of pesticide load in young great and blue tits' by the CLM and the NIOO-KNAW was published in the Netherlands. In addition, 14 different pesticides were found in 10 samples of young great and blue tits, mainly insecticides. The question arose as to whether this would also be the case in Flanders. (89). The following samples were collected:

- 95 nests with dead great tit and blue tit chicks from gardens suspected of using pesticides in the vicinity;
- 7 nests from forest area (hereafter referred to as forest nests) where there is no suspicion of pesticide use nearby.

Nests were selected for the garden nests, with the applicant confirming that there is a suspicion of the use of pesticides in the vicinity of the nest box.

The samples were tested for more than 500 pesticides and their metabolites. The analyses were performed using two methods:
- GC-MSMS: gas chromatography in combination with an improved mass spectrometry;
- LC-MSMS: liquid chromatography in combination with an improved mass spectrometry.

In total, 36 different pesticides were found in the 95 nests from the gardens. This included fungicides, insecticides and herbicides. It was very noticeable that DDT is the most commonly found pesticide: in 89 of the 95 garden nests and in 4 of the 7 nests from the forest areas. However, the use of this insecticide has been prohibited since 1974. (89)

The highest concentrations found were of the following pesticides:
- captan (fungicide): 1,700 mg/kg;
- dodine (fungicide): 0.394 mg/kg;
- fipronil (insecticide): 0.340 mg/kg;
- permethrin (insecticide): 0.230 mg/kg;
- DDT (insecticide): 0.170 mg/kg.

The levels of the 36 pesticides in the tits are much lower than their respective LD50 values. When using these LD50 values to determine the harmfulness on the tit chicks, however, there are a number of caveats to make:
- The available LD50 values were initially determined for other bird species, such as quail and wild duck. These LD50 values are not available for great tits and blue tits, and certainly not for new-born tits; (89)
- One can question the effect of the simultaneous presence of different pesticides, not least in a nest where 8 different types were measured. There is very little known about the combined effect of these substances and to what extent they influence each other's effect. (89)

The full report (in PDF) can be freely downloaded. Since the pesticides were found in tits, it can be suspected that they are also present in the soil of private gardens.

2.2.4 Air and deposition measurements

2.2.4.1 VMM - Dioxins and PCBs - continuous monitoring

The VMM measures dioxins and PCBs in deposition samples. The analysis package has varied over the years:

- from 1995: 17 toxic dioxins,
- from 2002: the deposition of the most toxic polychlorinated biphenyl compound PCB126,
- from 2012: all 12 dioxin-like PCBs,
- from 2015: in a number of samples near scrap metal companies, the analysis is limited to the group of PCBs.

Between 1995 and 2009, the VMM organized only two 1-month measurement campaigns at most locations: 1 during the spring and 1 during the autumn. From 2009, deposition at most locations is measured 4 to 6 times a year, each for 1 month. To this end, the number of measurement points was reduced from about 70 to about 15.

The measurement location in residential or agricultural areas provides information about a possible impact on the food chain. The industrial measurement site is often closer to the potential source and therefore provides information about the emissions from that source. In Genk and Menen there is both an industrial measuring location and one in the residential area.

In the period June 2017 - April 2018, 15 measurement locations were classified as follows:
- the threshold values are tested at 9 measurement points:
  - 3 measurement points in an agricultural area;
  - 6 measurement points in a residential area.
- at 6 measurement points there is no testing against the threshold values:
  - 6 measurement points in an industrial area.

Most measurement points are located north-east of the potential source because there is a dominant south-west wind in Flanders. This also means that the reported dioxin and PCB levels do not correspond to the real average deposition for that municipality or for Flanders.

Results are currently available until April 2018 for dioxins and PCB:

- Threshold values are still being exceeded: the monthly average deposition was occasionally higher than the monthly average threshold value at 6 of the 9 measurement locations.
- PCB values near scrap processing companies are still higher.
- Strict monitoring of dioxin and PCB depositions remains necessary to evaluate the impact of ongoing and future environmental enforcement actions.

The latest results also show that higher PCB values are still being measured near scrap processing companies. This is especially the case in Kallo, Genk and Ghent. The direct impact on the population is small because the companies are much further from the residential areas. The deposition values at the measurement locations in Menen and Willebroek are much lower than at the above locations. However, the companies in the vicinity of the latter measurement points are closer to the adjacent residential areas, so that the depositions in those residential areas are sometimes higher than the threshold value. The PCB values drop quite quickly as the distance to the scrap metal company increases. This means that the region with contamination is rather small. If there is habitation, the Agency for Care and Health advises not to eat eggs from free-range chickens. If necessary, the Federal Food Agency carries out measurements to ensure that the commercial food chain is not contaminated. Grass and crops intended for animal feed may also be examined.

In a number of regions, the so-called focus areas, the VMM has been following dioxin problems for many years (Beerse, Deinze, Oostrozebeke-Wielsbeke and Zelzate). Deriving a trend remains difficult, however. We note that the measured values can fluctuate and that periods with low measured values are sometimes interrupted by an occasionally higher value. Monitoring therefore remains necessary.

No information is currently available on a link between concentrations in air and deposition and effective concentrations in soil.

2.2.4.2 VMM - heavy metal deposition - continuous monitoring

The VMM performs the following measurements of heavy metals in deposition. Results are available from 2000-2002 until April 2019. The monitoring network has been adapted several times over the years. The following measurement data are available for 2018:

Metals in particulate matter

- 9 measurement locations near industrial areas (Genk, Hoboken, Beerse and Zelzate)
- 2 measurement locations in cities and agglomerations (Antwerp, Ghent)
- 1 measurement location in a background area (Koksijde)

A sampling device samples the heavy metals in particulate matter on a daily basis. Sampling is done at 1.58 m above the ground. The lab analyses the filters with ICP-MS. The VMM measures the following parameters: arsenic, cadmium, chromium, copper, manganese, nickel, lead, antimony and zinc.

In the period from 1 May 2018 to 30 April 2019, there was only an exceedance of the European target value of arsenic at two measurement locations in Hoboken and of cadmium at one measurement location in Hoboken. The limit and target values were complied with at the other measurement locations.

Metals in total deposition

If sampling is only done during the periods with precipitation, we call this wet deposition. If sampling is also carried out during the dry periods, this is called total deposition. The sampling and analysis have been carried out since January 2015 in accordance with EN15841.

- 7 measurement locations in industrial areas (Hoboken and Beerse)
- 2 background measurement locations (Koksijde and Bonheiden)

The VMM measures the following parameters: arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead and zinc. The measurements of heavy metals in total deposition are mainly done around non-ferrous metal companies and in background areas.

For the total deposition, the particles are collected for 28 days in a precipitation jar fitted with a funnel. The jar stands on a tripod, the top edge of the jar is 1.8 to 2 m above the ground.

Metals in wet deposition

- 1 background measurement location (Koksijde)

Wet deposition is sampled using wet-only deposition collectors. These devices open only during periods of precipitation. The VMM measures the following parameters: arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead and zinc.

Currently, all results are available from January 3 to June 18, 2019.
The depositions in the focus areas are increased compared to the measurement locations at a background location.

2.2.4.3 VMM - PAH deposition - continuous monitoring

The VMM measures PAH in ambient air and in deposition.

- in ambient air at eight measurement locations;
- in deposition at six measurement locations.

The measurements in air have been carried out since 2000, those in deposition since 2005. From 2011, the VMM has taken deposit samples all year round. Previously there were only 2 monthly measurements per year.
The measurements focus on the parameters benzo(a)pyrene (B(a)P), benzo(b)fluoranthene, benzo(k)fluoranthene (B(k)Flu); indeno (1,2,3-cd pyrene).

Deposition Ng/m^2.day
Air: ng/m^3

The most recent results (period 2016-2018) (90) show that the average concentration of benzo(a)pyrene in air in Flanders is currently 15 times higher than the level that is considered negligible from a public health point of view (namely, 1 extra cancer in 70,000 inhabitants compared to 1 in 1,000,000). The 3-year average concentrations were at least twice as high at all measurement locations as at the national reference measurement location. The concentrations were significantly higher in winter than in summer. As possible explanations, the report refers to higher emissions from wood burning in winter, more stable weather and less dilution in winter, decomposition in the summer months due to photo-oxidation and losses of PAH in the summer due to reaction with ozone during sampling. After years of decreasing concentrations, a slightly increasing trend was again observed.

The annual average deposition of benzo(a)pyrene remained more or less constant over the period 2012-2017. When the results of measurements of PAHs in ambient air (PM10) are compared with the measurements in deposition, a correlation between both measurement techniques is seen over longer periods. The correlation is certainly not perfect, but at the locations with the highest PAHs in ambient air, we almost always measure the highest PAHs in deposition. In 2016 and 2017, a screening was also carried out in the vicinity of 8 companies with possible PAH emissions. Increased values were measured at 2 of the 8 locations. These measurement locations were added to a fixed monitoring network. This concerned a tar-processing company and a company that produces and recycles railway sleepers.

2.2.4.4 VMM Current air quality measurements - continuous monitoring

The VMM continuously measures the content of particulate matter, ozone, nitrogen dioxide and sulphur dioxide at various locations in Flanders. The most current data can always be consulted via a map on the VMM website. These data can give an indication of where, for example, emissions of nitrogen dioxide as a result of traffic have an effect on air quality. In these areas, higher emissions of other parameters related to traffic into the soil can also be expected. The VMM's measuring network, however, consists of a relatively limited number of measurement locations.

2.2.4.5 Curieuze neuzen – one-off measurement

During the 'Curieuze neuzen' project, the NO_2 concentration in air as an indication of air contamination from traffic was measured at 17,843 locations in Flanders. The measurements were made during the month of May 2018.

NO_2 was collected in a measuring tube with triethanolamine and then analysed. The measurements were calibrated by also placing measuring tubes at the VMM measurement points mentioned in the previous section.

Given the larger number of measurement locations and given the choice of locations specifically to measure traffic emissions, these results provide a good indication of the traffic congestion in Flanders. It can be expected that other parameters (such as heavy metals, PAHs) that are emitted by traffic at these locations are present in larger concentrations and that they can potentially also lead to higher concentrations in the soil.

The results show that the NO_2 concentration can vary greatly over a short distance, even within the same street. Busier traffic, continuous buildings and start-stop traffic at intersections and traffic lights result in increased NO_2 concentrations. The NO_2 concentrations differ remarkably between cities and also between the city centre and the city outskirts. The highest concentrations are measured in the two major cities in Flanders, Antwerp and Ghent, followed by Mechelen and Ostend. Increased NO_2 concentrations are a problem not only for large cities. A quarter of small towns and municipalities have at least one measurement location where the EU standard is exceeded. Even in small rural municipalities one can find “red hotspots”. These are locations in the centre with greatly increased concentrations relative to the surrounding streets. Due to the many measurement locations in the ‘Curieuze neuzen’ project, we get a very good picture of where these red hotspots occur. They are often located at intersections with traffic lights or roundabouts, where traffic gets stuck in the morning and evening rush hours and local traffic jams occur. (91)

A new phenomenon that emerges from Curieuze neuzen is “black crossroads”. These are measurement locations with very high concentrations. They are typically busy traffic arteries, often two-lane roads, surrounded by ribbon development and located at intersections. Not only the traffic volume, but also the traffic flow plays an important role in air quality. (91)

Such locations may also be locations where the soil is more heavily diffusely burdened by traffic.

The data can be consulted at
http://www.standaard.be/curieuzeneuzen/map/#10.28/50.9543/4.0551

2.2.5 Human Biomonitoring

2.2.5.1 Flemish human biomonitoring program - continuous measurement program

The Flemish Human Biomonitoring Program was started in 2002 by the Flemish Center of Expertise on Environment and Health. Human biomonitoring (HBM) measures the exposure to environmental contaminants and potential health effects in the human body, e.g. in blood and urine samples. After a pilot study in 1999, a large-scale HBM study was started in Flanders in 2002 for the first time.

In the **first human biomonitoring program (2002-2006)**, eight focus areas with different environmental pressures and three age groups were examined. In total, approximately **1,600 participants per age group participated in the study**. A study was conducted into the parameters cadmium, lead, PAH, dioxins, PCBs and chlorinated pesticides (HCB).

The results for young people showed that high levels of PCBs and DDE were found in the port areas of Antwerp and Ghent. Exposure to chlorinated substances was higher in the Ghent canal zone, while cadmium was higher in Antwerp. The DDE values were also higher in rural areas, the Olen region and around the Albert Canal. The cadmium values were also increased in rural areas.

An increase in PCBs and HCB and also DDE and lead in neonates were measured around the Menen incinerator. An elevation of cadmium was measured around the Harelbeke incinerator, benzene around the Roeselare incinerator, and lead around the Wilrijk incinerator. Consequently, this contamination appears to be very local.

Participants from the fruit region have reduced levels of PCBs, lead and cadmium

In the rural areas of East and West Flanders and Flemish Brabant, elevated values of all compounds containing chlorine (dioxin-like substances, PCBs, DDE and HCB) had been observed in the study of new-borns and adults.

The results are summarized in the diagrams below.

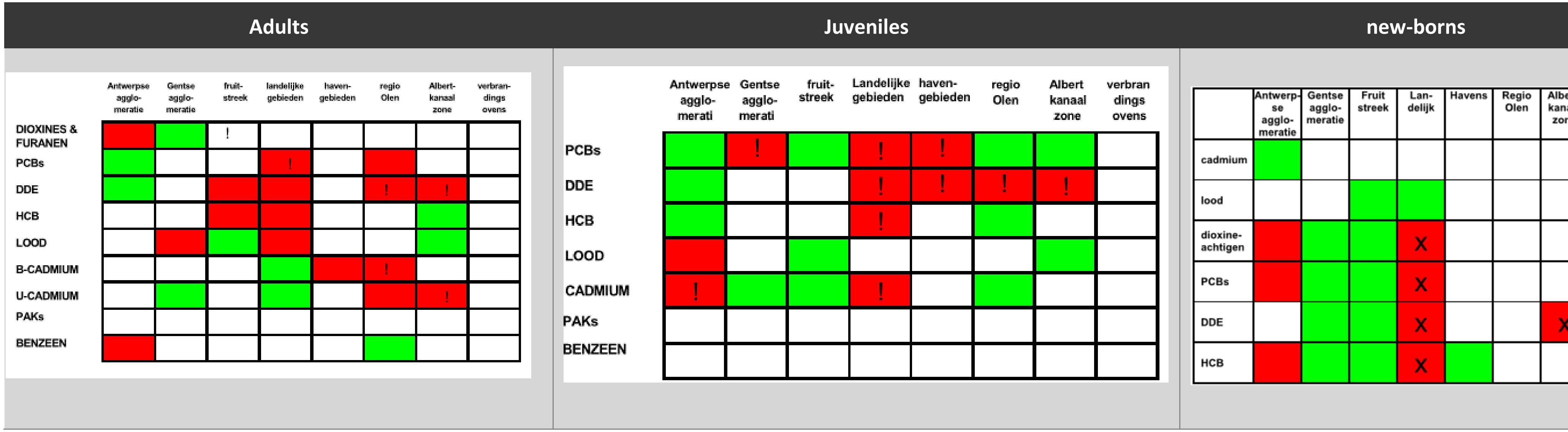


Figure 2-8: schematic representation of results first human biomonitoring program (2002-2006)

Colours indicate whether the area value was above (red), below (green) or not different from (white), the reference average. The symbol (X or !) means that there are more high readings in that area (above the reference P90).

The **second human biomonitoring program (2007-2011)** was interpreted differently.

- The first part aimed to determine Flemish reference values. In this campaign, a broader spectrum of contaminants and health effects was measured: heavy metals and POPs, new pesticides, plasticizers in plastic, flame retardants, etc. In total, more than 50 different biomarkers for exposure and effect were examined in three different age groups.
- In a second part, a strategy was developed to systematically study areas of interest with biomonitoring. Two areas were eventually studied, Genk South and the Menen region. In these areas, **200 young people** aged 14-15 were studied and the measurement data were compared with the Flemish reference values.

The following conclusions could be drawn from the second program that may be relevant in the case of diffuse soil contamination:

- Living in urban areas means more heavy metals in the body: cadmium, lead, manganese and mercury were found in higher concentrations among participants from urban areas.
- Living in a non-urban area has been associated with higher levels of benzene in the body.
- Open fires have been associated with higher values for dioxins.
- Consumption of self-farmed eggs and self-caught fish gives higher values of older pesticides (HCB, DDT), of dioxins and of perfluor derivatives in the blood.

The **third human biomonitoring program (2012-2015)**:

- Flemish reference values were again determined in different age groups, both for historical contaminants and for newer contaminants.
- In addition, a third hotspot study was also conducted among young people in the Ghent canal zone. In addition, time trends were also studied.

The following conclusions could be drawn from the third program that may be relevant in the case of diffuse soil contamination:

- A link was found between some pesticides (dimethyl alkyl phosphates and dialkyl phosphates) and living < 1 km from vegetable cultivation.
- A link was found between urban living and hexachlorobenzene (adults), arsenic and thalium (young people).
- A link between PFOS, chlorinated pesticides and PCBs and the consumption of local eggs. For new-borns, this link was also found between PFOS and the consumption of local vegetables.
- A link was found between the consumption of local vegetables and DDE and DDT.
- A link was found between the use of garden compost and PCBs and chlorinated pesticides.

A **fourth human biomonitoring program (2016-2020)** has also been started.

- In doing so, attention is given to monitoring time trends in Flanders, the emergence of new chemicals in our environment, a comparison with health-based guideline values, factors that influence exposure and the relationship between exposure and (early) health effects.
- For the upcoming measurement campaign, it was decided to focus on three central themes: indoor environment, green space and pesticide-free food, each in relation to health. For this cycle, **600 young people** across Flanders will be sought to participate in the research.

(92)

The data from the biomonitoring programs includes:

- Exposure markers in urine, blood, umbilical cord blood and hair: persistent substances, heavy metals, perfluorinated compounds, phthalates, bisphenols, flame retardants, parabens, musks, UV filters, pesticides, benzene marker, PAHs marker
- Effect markers: DNA damage, oxidative stress, NO in breathing air (inflammatory marker), asthma, allergies, metabolic hormones and reproduction hormones, thyroid function, renal function markers, puberty data, growth and development, well-being, neurological tests, blood count, BMI, blood pressure
- Perception data
- Data from questionnaires: food, home-grown food, home environment, socio-economic status, migration background
- External data on an individual level: meteorological data, air quality, pollen, noise

The reports are publicly available and can be requested via the website: http://www.milieu-engezondheid.be/nl/onderzoeksresultaten (PDF format)
Data for individual participants and geolocation data can be requested: submit an application form to the Supervisory Committee of the Flemish Center of Expertise on Environment and Health, for the application form email to: info@milieu-en-gezondheid.be

Biodatabase samples: submit application form to the Supervisory Committee of the Flemish Center of Expertise on Environment and Health, for the application form email: info@milieu-en-gezondheid.be

The aggregated Flemish data is also entered into a European platform "IPCHEM", within the European HBM project HBM4EU (see Section 2.2.7.2).

The results of some specific sub-studies of the biomonitoring program are explained below.

2.2.5.1.1 PAH

During a measurement campaign at various locations in the Menen and Genk South region, polyaromatic hydrocarbons (PAHs) were measured in the air and in the urine. The aim was to investigate why the young people in those regions had more PAHs in their bodies, compared to the results of studies across Flanders. The Expertise Center examined 200 young people (14-15 years) in Genk South and the Menen region. The results were compared with those of 210 young people from all over Flanders.

Compared to the young people from Flanders, a higher exposure to certain heavy metals (cadmium, chromium, copper, thallium and arsenic) and PAHs was found. Differences were also found for some health parameters such as hormone levels, DNA damage and ability to concentrate. This study found no association between the air concentrations of PAHs and urinary OH-PAH decomposition products in humans.

In Menen and Genk/Diepenbeek, larger quantities of PAHs in the air were measured compared to the background location. Burning of biomass, such as wood, was a major source of PAH in all areas. In addition, traffic was one of the major sources of PAHs in the residential environment at most measurement locations in Genk/Diepenbeek and Menen. Whether traffic or wood burning was the main source depended on the location of the measurement. (93)

2.2.5.1.2 Hormone-disrupting pesticides

In April 2013, the Department of Environment and Health published a study into human biomarkers for priority endocrine disrupting pesticides in Flanders. A selection was made of priority pesticides for which a measurable biomarker is available according to international literature. The following pesticides were selected for optimization in the field study:

Table 2-3: persicides and biomarkers selected in this study (94)

Active ingredient	Type of pesticide	Biomarker
glyphosate	herbicide	glyphosate in urine
chlorpyrifos	organophosphate pesticide	TCPy in urine
mancozeb	fungicide	ETU in urine
linuron	herbicide	3,4-DCA in urine

A total of 11 participants were recruited, most of whom live in the fruit region in Limburg. Young people between 14 and 15 years old could participate.

The aim of the study was to optimize biomarkers so that recommendations could be formulated for future biomonitoring campaigns. However, the following things could already be observed:

- Urinary glyphosate was above LOQ (73%) in 8 of 11 participants; AMPA was detectable in 10 of the 11 participants (91%). Based on the questionnaire data, it was found that for 3 out of 11 persons glyphosate had been used in the past week or two weeks by one of the family members near the house (outdoors). However, the glyphosate or AMPA values in the urine of these 3 participants were no higher than in the other participants. The period between glyphosate use and measurement in the urine may be too long, from the literature it is known that glyphosate and AMPA are removed from the body rapidly (from hours to days).
- The specific metabolite of chlorpyrifos could not be detected in any of the participants. The participants in this study may have had little exposure to chlorpyrifos because recruiting was in a typical fruit region, while chlorpyrifos is mainly used in vegetable cultivation. The season may also play an important role (highest usage in the spring vs. sampling in the summer). The questionnaires revealed no use of chlorpyrifos or other organophosphates.
- Less specific organophosphate metabolites were detected. The questionnaires revealed no specific use of organophosphates, but the relatively high concentrations of a number of metabolites suggest that participants were unconsciously exposed to these organophosphate compounds.
- The ETU metabolite (ethylene thiourea) of mancozeb: what was especially striking was the large variation between the different participants. The questionnaire data revealed no specific use of mancozeb or maneb (also breaks down to ETU) that may explain the high ETU concentrations.
- Unlike ETU (Linuron marker), there was little inter-individual variation for 3,4-DCA. The questionnaire data indicated that 2 participants were exposed to linuron 2 weeks before sampling, but this was not reflected in the 3,4-DCA levels.

If the values of all the biomarkers in each participant are compared with the living environment, we often see that the adolescents with the highest biomarker values also live closest to fruit cultivation, vegetable cultivation, a field or a lawn and vice versa, although this is not always the case.

The study report is freely available. The individual analysis results cannot be freely downloaded. (94).

2.2.5.1.3 Brominated flame retardants and perfluorinated compounds

In June 2009, a study commissioned by the LNE was carried out with the aim of providing an initial start for a risk analysis of brominated flame retardants (BFRs) and perfluorinated compounds (PFCs) for Flanders and to formulate accompanying policy recommendations. (95)

In this study, samples were collected from vegetables, meat, eggs, cow's milk, drinking water and fish. For the cultivated food, samples were taken from both organic and classical agriculture. In addition, dust samples were collected in 46 homes and 10 offices. Finally, measurements were performed in human blood and breast milk.

With regard to the measured BFR counterparts in food samples, the levels in Flemish soil products, depending on the type of sample, were comparable (e.g. fruit and vegetables), lower (e.g. eggs and cow's milk) or higher (e.g. meat) than the values found in other foreign studies.

Regarding the PFCs, comparison of the dietary levels with the literature data was difficult due to the limited studies available and the lack of information on the food types analysed. Generally we can say that for PFCs in food grown in Flanders too, comparable (e.g. vegetables/fruit and meat), lower (e.g. cow's milk) or higher (egg) levels were sometimes measured than in other studies.

Just as for BFRs, the median levels in offices for the PFCs in dust were higher than in homes. No statistical differences were found between the levels in homes with many and homes with few carpets/curtains or electronic equipment. In comparison with the literature, the median levels of PFOS and PFOA in dust from Flanders were lower than in German, English and Swedish houses. Hardly any literature was available for the other components.

Within the current project, PFCs were also measured in human blood and breast milk. In comparison to the international literature, sometimes lower and sometimes higher levels were measured in human serum. In contrast, compared to foreign studies, the PFOS and PFOA levels measured in Flemish breast milk were significantly higher.

For both substance groups, it is estimated that the total intake is mainly determined by diet.

Regarding the toxicological effects of BFRs and PFCs, there is still a need for relevant toxicological information:

- both contaminant classes were included in the current human biomonitoring campaign so that further studies can be conducted.
- In another study, BFRs were also measured in 100 breast milk samples from the rural areas of the human biomonitoring campaign of the first generation of the Flemish Center of Expertise on Environment and Health. (95)

2.2.5.1.4 Dioxins, PCBs and DDT in soil and egg samples

This project arose from the policy actions in the “action plan region Menen” that was drawn up in the context of the Phase Plan, the policy translation of the results of the human biomonitoring campaign that ran in 2010-2011 in the Menen region. Significantly lower levels of dioxins, PCBs and DDE were found in the blood of 199 young people aged 14-15 than in the blood of peers from general Flanders. These lower levels were found to be partly related to a lower consumption of locally grown food in the Menen region. In the past, however, high values were measured in the Menen region for dioxins and PCBs in ambient air, deposition samples, soil, eggs and in humans (human biomonitoring campaign 2002-2006). The threshold values for the deposition of dioxins and PCBs are still regularly exceeded in the vicinity of the scrap processing industry in Menen. The study was designed to determine whether it was safe to eat eggs from the garden in this region.

15 people participated in the study. The researchers took soil samples from the chicken coops of all 15 participants. The researchers collected eggs from 14 participants. The researchers placed deposition jars in the garden of 4 participants. For the same period, deposition measurements are also available from both the VMM monitoring locations in Menen: one in the 'Grensland' industrial zone and one in the adjacent residential area. The results of this study in the Menen region with an industrial environment were compared with the results of other studies on levels in chicken eggs from private individuals. (96)

This produced the following results:

- Dioxins: no significant differences compared to the rest of Flanders in soil and eggs
- Dioxin-like PCBs: significantly higher median values in soil compared to the rest of Flanders, not for eggs
- Marker PCBs: no significant differences compared to the rest of Flanders in soil and eggs
- DDT components: significantly higher levels of DDD in eggs.

2.2.5.2 <u>Local</u>

2.2.5.2.1 Exposure study in Hoboken - lead - one-off study

Years of non-ferrous metal production have contaminated the Hoboken environment with heavy metals such as lead and cadmium. Since 1981, biannual blood tests have been performed on children between 1 and 12 years old in the Moretusburg/Hertogvelden district (up to 650 m from the company boundary). The results are compared per group (age, attending school and/or living) from 1993 onwards with a control group (children of the first kindergarten and the first grade of a school located in an urban area about 2.5 km from Moretusburg;

In order to ensure that there is no exceedance of the guideline value for lead in the blood in the wider area of Hoboken (i.e. outside the Moretusburg and Hertogvelden districts), a one-off, broader study was conducted in January 2008 on more than 500 children between 2.5 and 7 years old. At the same time, the presence of lead in the environment was measured in Hoboken at home and at school. The data for lead in the blood in the children on the one hand and lead in the environment on the other hand were processed together. (97)

The report of this study can be freely downloaded. The measurement data themselves are not freely available.
https://www.lne.be/sites/default/files/atoms/files/loodplan_versie%20ter%20publicatie.pdf

2.2.5.2.2 Exposure study in the Noorderkempen - cadmium and arsenic - one-off study

At the beginning of 2006, the Flemish Agency for Care and Health, Department of Public Health Monitoring, together with the Department of the Environment, Nature and Energy, the Medical Environmental Experts at the LOGOs Noorder- en Zuiderkempen, the OVAM and VMM started a large-scale exposure study in the Noorderkempen.

The study was conducted in the municipalities of Mol, Balen, Lommel, Overpelt, Neerpelt and Hechtel-Eksel (= control group). The intention was to investigate whether the people who live in the living environment of the non-ferrous companies still have an increased body load of cadmium and arsenic in 2006. This is important because an increased amount of these metals can lead to health damage as concluded in the KU Leuven study) after measurements on blood and urine in the 1980s-1990s. We also wanted to investigate whether there may be a problem with lead in this region.

A total of 1,217 adults (aged 20-79) were studied. Cadmium and arsenic levels were measured in the blood and urine of these people. In addition, a total of 338 toddlers aged between 2.5 and 6 years were examined. Some attended school in the research areas, some in the control area. The toddlers were examined to see how much lead they have in their bodies.

Additional measurements were made in 100 participants and at 14 public places (schools, churches, etc.): cadmium, arsenic and lead levels were determined in the garden soil, the vegetables, the dust in the house, well water and air.

The data was compared with the older KUL measurement data (the so-called Cadmibel and Pheecad studies) (98)

The study shows that cadmium concentrations were higher than in the control area. There was a decrease compared to the previous studies. The lead in the blood of preschool children is also higher in children who go to school within a radius of 2 km around the factory. The population mainly comes into contact with the heavy metals through food (including home-grown vegetables).

2.2.5.3 International

2.2.5.3.1 Europe: ESBIO, DEMOCOPHES and HBM4U - data are continuously updated

At European level, there have already been several initiatives on human biomonitoring. The ESBIO project was running in the period 2005-2007. This project attempted to establish a coordinated approach to human biomonitoring in Europe. After all, various procedures were used in such studies within Europe, so that the data was often not comparable. An inventory was made of European human biomonitoring activities. The inventory included information about the people and laboratories and entities involved with expertise in specific fields. They developed protocols to implement a harmonized HBM program in Europe.
https://cordis.europa.eu/project/rcn/75106/factsheet/en

From 2009 this was continued by **COPHES**. COPHES consists of 35 institutes in 27 EU countries. They are starting a first pan-European pilot project. **Democophes** was the pilot project that tested the feasibility of this harmonized approach to human biomonitoring in 17 European countries. The Belgian part of this research was carried out by various research groups, on behalf of all ministers of

Environment and Health of the various policy levels in Belgium (collected in the National Cell for Environment and Health).

From October 2011 to January 2012, 6 contaminants were measured in the urine and hair of 129 school-aged children (ages 6 to 11) and their mothers. These included mercury, cadmium, cotinine, triclosan, bisphenol A and phthalates. The established level of contaminants in this Belgian study population was low and was not known to pose a health problem. The measurement results could be explained by the information from the questionnaires regarding lifestyle, diet and living environment. Several reports with discussion of the results can be downloaded from the website: http://www.eu-hbm.info/euresult/scientific-publications

A new large-scale European project, **HBM4EU** (2016-2021), is currently ongoing, which is intended to consolidate further cooperation at European level. The VITO is co-coordinator in this project and several other Flemish and Belgian partners are also involved, including the Flemish Center of Expertise on Environment and Health (92). The HBM4U project builds on the DEMOCOPHES project. A total of 28 European countries are participating.

In this project, a list of priority substances was identified in two phases:
Anilines, Bisphenols, Cadmium, Chromium VI, Arsenic, Lead, Mercury, Emerging substances, Flame retardants (62 parameters - Brominated flame retardants and organophosphorus compounds), PAHs, PFAS, Phthalates, Acrylamide and 4 Aprotic solvents: (- 1-methyl-2-pyrrolidone (NMP), 1-ethylpyrrolidin-2-one (NEP), N, N-dimethylacetamide (DMAC), - N, N-dimethylformamide (DMF), diisocyanates, mycotoxins, pesticides, Benzophenones.

Attention is also paid to how to deal with mixtures of these substances.

A third phase to identify priority substances is ongoing.

For these substances, existing information will be collected as much as possible and made available via the IPCHEM platform (Information Platform for Chemical Monitoring Data, see also Section 2.2.7.2) and it will be determined which concrete policy questions can be answered with the existing data.

The HBM4U online library contains an overview of existing HBM studies, protocols and standardized questionnaires. This can be consulted via:
https://www.hbm4eu.eu/online-library/?mdocs-cat=mdocs-cat-10&mdocs-att=null

https://www.hbm4eu.eu/the-substances/
https://www.lne.be/hbm4eu-europese-humane-biomonitoring-initiatief

2.2.6 Manure

2.2.6.1 Manure - emissions of medicines from veterinary use - one-off measurement campaign

The VMM has already conducted studies into the emissions of medicines from veterinary use into surface water. For this purpose, manure samples from slurry houses were analysed in a preliminary study. In a second study, an attempt was made to quantify the amount of antibiotics that were brought onto the land and which subsequently end up in surface water (41).

100 slurry samples were taken by the "Mestbank" at the time of basement emptying or after manure transport. 91 samples concerned pig manure, 9 calf manure.

The samples were analysed for antibiotic residues using liquid chromatography tandem mass spectrometry (LC-MS/MS). Of the 100 slurry samples, there were 4 samples that did not contain antibiotic residues. Between one and 15 different antibiotic residues were detected in the other 96 fertilizer samples. The antibiotics doxycycline, lincomycin and sulfadiazine were most frequently detected. The antibiotics neomycin, oxytetracycline, doxycycline and sulfadiazine were found in the highest concentrations.

From these data, it was calculated that an average of 5,314 kg of veterinary antibiotics are brought on the land each year by veal calves and pigs together. (41)

2.2.6.2 Flemish Land Authority (VLM)- sampling notification Internet portal - continuous monitoring

The Sampling Reporting Internet Portal (SMIL) is an internet application for samplers and employees of approved laboratories. All samples and results of analyses, both of soil and manure, must be reported to the Flemish Land Agency via the SMIL.

The following samples must be reported in the SMIL:
- soil sampling for nitrate residue determination
- soil sampling for vegetable consulting
- fertilizer sampling of animal manure and other fertilizers

The analyses that are done are the parameters nitrate, ammonium and phosphate.
https://www.vlm.be/nl/doelgroepen/laboratoria-en-staalnemers/SMIL/Paginas/default.aspx

2.2.7 Other

2.2.7.1 Environmental inspectorate sampling

The enforcement department checks the emissions of companies on the one hand by testing the emissions of the monitoring results reported by companies as well as by their own sampling. The number of samples is reported annually in the environmental enforcement report. This report can be downloaded for the years 2010, 2012, 2013, 2014, 2015, 2016 and 2017. The results of the analyses as well as the parameters that were analysed are not freely available.

The environmental enforcement report shows that the services of the environmental inspectorate carry out sampling of waste, soil, groundwater and waste water. In 2017 it concerned, respectively, 568, 5, 1 and 1,495 samples. Each sample is analysed for different parameters so that several thousands of analyses have been performed. In previous years too, it appears that the majority of analyses were carried out on waste water and waste.

Table 2-4: Number of samples taken by the enforcement department

Year	Waste	Soil	Groundwater	(waste) water	air
2010	865	23	54	2009	135
2012	631	9	10	1959	128
2013	588	18	4	1962	119
2014	662	10	1	944	139
2015	628	1	5	1770	160
2016	629	0	55	1483	121
2017	568	5	1	1495	178

Waste water sampling:
Every year, the Enforcement Department draws up a schedule for the waste water checks to be carried out in the following year. The checks fall into two main groups. On the one hand, there are the random samples, during which an (unannounced) check takes a scoop sample of the discharged waste water. This results in a snapshot of the quality of the waste water discharged at that time. On the other hand, there are extensive inspections, whereby an approved laboratory places a sampling device on behalf of the Enforcement Department and follows the discharge for a few days to weeks.

Air and sound measurements
In 2017, 178 air measurements were made by the environmental inspectorate. In 2017, a number of specific measurements were carried out in the context of limiting the emissions of dioxin-like PCBs, with the main focus being on large scrap processing companies in the vicinity of residential areas and agricultural areas. The enforcement department also co-finances the deposition measurements of PCBs carried out by the VMM (see the discussion in Section 2.2.4).

During the course of 2017, a number of immission measurements were carried out in collaboration with the VMM and VITO. This mainly concerns measurements of VOCs, PAHs and asbestos in the ambient air.

2.2.7.2 IPCHEM

The IPCHEM platform is the “Information platform for chemical monitoring”. It is a platform of the European Commission that collects links to monitoring data from Europe. It is structured as 4 modules: Environmental monitoring, Human Bio-Monitoring, Food and Feed, Products and Indoor Air.https://ipchem.jrc.ec.europa.eu/RDSIdiscovery/ipchem/index.html

Data from this database could possibly be used to investigate certain links between sources of diffuse contamination, parameters and suspected locations.

The following data regarding soil are found via IPCHEM:

- **Biosoil data**: the BioSoil project was part of the monitoring of forests. The project included the analysis of a number of soil samples for the parameters aluminium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel nitrogen, phosphorus, potassium, sodium, sulphur and zinc. The samples were collected in 2006
    - Responsible organisation European Commission - Joint Research Centre

- Name Marc Van Liedekerke - marc.van-liedekerke@ec.europa.eu
- Licence of use:The use of the data is allowed to the European Commission Services and European Agencies only, Access conditions The access is allowed to European Commission Services and European Agencies only

– **POP-Dioxin-Database** (Germany): This database forms a central portal that provides access to German and international measurement programs and research projects on PCB and PCDD/F in air, soil, water, sediment and biota. The oldest data dates from 1986. The dataset contains approximately 82,000 samples and 620,000 measurement results, including calculated TEQ values. The data can be consulted after sending a motivated request to: https://popdioxin.uba.de/DioxinWSClient/logon.do?language=en
  - Responsible organisation German Environment Agency
  - Point(s) of Contact: Gerlinde Knetsch - gerlinde.knetsch@uba.de
  - Conditions of data access and use: Licence of use Detailed information on data policy are available in DioxinDB web site
  - Access conditions: Open access to data published in provider's website is allowed after registration. http://www.dioxindb.de/f_daten_proben_e.html

– **ESB-UBA - Environmental Specimen Bank of Germany**: this database analyses and archives samples from ecosystems all over Germany. The samples come from soil, plants, algae, mussels, fish, gulls and people (blood and urine). Analysis data is available for the following parameters: Metals, chlorinated hydrocarbons, DDT and decomposition products PAH, phthalates, bisphenal A biocides, PFAs, musks, alkyl spirits, pyrrolidones, parabens and perchlorate. The data was collected over the period of 1981 and is still ongoing.
  - German Environment Agency
  - maria.ruether@uba.de
  - https://www.umweltprobenbank.de/en

– **Pharms-UBA - Pharmaceuticals in the environment:** this database contains data on the worldwide occurrence of pharmaceutical substances in the environment, which was collected from 1,016 publications and 150 review articles. It contains data on concentrations of human and veterinary pharmaceuticals in surface water, groundwater, drinking water, manure and soil. This resulted in 123,461 data lines spread over 71 countries within the 5 UN regions. 631 different pharmaceuticals were detected above the detection limit. 17 substances were found in all regions.

  Each line in the database contains 32 fields including substance name, CAS number, the matrix in which it was measured, location, time of sampling, number of measurements, concentration in original and standardized units, detection limit, analysis method and quality assessment, source of contamination if known, literature reference, language of publication and type of publication.

  The data can be freely downloaded in Excel or Access. The database contains 5,059 data points from Belgium, from the period 2000-2010. 2,641 data points originate from surface water, 6 from dust, 222 from sediment, 5 from industrial waste water, 228 from suspended particulate matter and 1,957 from the influent and effluent of water treatment plants.

https://www.umweltbundesamt.de/dokument/database-pharmaceuticals-in-the-environment-excel

3 DATA REGARDING MAPS AND EMISSIONS

This section lists relevant geographic data and known data concerning emissions. This concerns maps of potentially suspected areas in the context of diffuse soil contamination or data concerning the potential sources of diffuse contamination. In addition, emissions data are also available. These are relevant because, depending on the distribution pathway, it may be expected that more diffuse contamination may arise in the vicinity of large emission sources.

3.1 GEOGRAPHIC DATA/MAP MATERIAL/GIS DATA

3.1.1 Flanders Spatialmodel *("Ruimtemodel Vlaanderen")*

In 2007, the VITO started to develop a spatial-dynamic land use model in collaboration with various parties with the aim of mapping out the existing situation and possible development of the changing land use in Flanders as faithfully as possible, and at a high resolution of 1 ha. in the form of time series of land use maps and spatial indicators derived from land use.

When carrying out the analyses, a very extensive GIS database is used consisting of the most recent spatial data layers of the highest quality available in Flanders. This concerns both spatial data layers that are collected from various sources within the Flemish government and derived data layers that are developed within the framework of the Spatial Model Flanders. An example of this is the land use database for Flanders that is developed and maintained by the VITO and which counts as one of the most important data layers of the Flanders Spatial Model. The land use database is a raster-based database at a resolution of 10x10 meters, from which various land use maps can be derived. (99)

The land use map 2013 uses the following data sources:

Table 3-1:overview data sources used in the land use map 2013 (99)

Name	Acronym	Reference year	Reference area	Update	Type of geo information	Owner - Distributor
Biological Valuation Map version 2.2	BWK	1997 – 2013	Flanders + Brussels	Ad hoc	Polygons	**INBO**
Agricultural use parcels	/	2013	Flanders	Annual	Polygons	**AIV/ALV**
Greenhouse model ALV	/	2015	Flanders	Ad Hoc	Polygons	**ALV**
Area Record Keeping 2013	RBH	01/01/2013	Flanders	Six monthly	Polygons	**Flanders Area**
Industrial areas	/	2014	Flanders	Continuous	Polygons	**VLAIO**
Space for Tourism and Recreation in Flanders study database	RuiTeR	2007	Flanders	N.A.	Polygons	**WES / Visit Flanders**
Flanders Green Card 2010	Green card	2010	Flanders	3-yearly	Raster	**AIVfANB**
Localization of green spaces in the Brussels Capital Region	/	2008	Brussels	Ad Hoc	Raster	**BIM**
Large-scale Reference Database	GRB	September 2013	Flanders	Continuous	Polygons, linen, points	**AIV**

Name	Acronym	Reference year	Reference area	Update	Type of geo information	Owner - Distributor
Vectoral cadastral parcel plans	CADMAP	2013	Flanders	Annual	Polygons	**AAPD**
UrbIS–Parcels & Buildings	UrbIS – P&B	2015	Brussels	Annual	Polygons	**CIBG**
UrbIS – Adm	UrbIS – Adm	2013	Brussels	Continuous	Polygons, Lines, Points	**CIBG**
UrbIS – Map	UrbIS – Map	2013	Brussels	Continuous	Polygons, Lines, Points	**CIBG**
Topographic map	Top10 Vector	1988 −2009	Flanders+ Brussels	Ad hoc (partial updates: per map sheet, per theme)	Polygons, Lines, Points	**NGI**
Enriched Crossroads Bank for Enterprises with CRAB link	VKBO	January 2015	Flanders	Continuous	Address - data	**AIV**
Crossroads Bank for Enterprises	KBO	January 2015	Flanders + Brussels	Continuous	Address - data	**FPS Economy**
Ghent Port Area business plots	/	December 2014	Flanders (port of Ghent)	Continuous	Polygons	**Ghent Port Company**
Number of inhabitants per address (beta version)	**/**	**March 2013**	**Flanders**	**Quarterly**	**Points**	**RR /AIV**

An area-wide land use file for Flanders at a resolution of 10 m was derived from these data sources. This land use database is a geo database with 4 raster layers, which represent 4 levels. These 4 separate grid layers can overlap: every 10 m grid cell in Flanders can therefore have a value on each of the 4 levels.

– On the first level, the ground cover is displayed on every 10 m grid cell.
– The second level provides information about the urbanized space (including built-up plots, recreational areas).
– On the third level, some multifunctional land use categories such as airports and outdoor recreation areas are defined.
– Finally, the fourth level contains the legal demarcation of the ports and the military areas.

As a result, the following land use categories can be consulted on the map. Several of these may be relevant as a source of diffuse soil contamination (orange).

Table 3-2: land use categories available in the Flanders Spatial Model (99)

	land use			
Level 1	Rough and thicket	Heath	**Orchard (standard tree)**	**Road**
	Deciduous forest	Coastal dune	**Orchard (low stem)**	**Railway**
	Poplars	Marsh	Cultured grassland permanent	**Water**
	Coniferous forest	Tidal flats and salt marsh	Building	Other
	Alluvial forest	**Field**	Other low green	
	Semi-natural grassland	Unregistered agriculture	Other high green	
Level 2	Other built-up plots	Marinas	Extraction, treatment and distribution of water	Retail trade
	Park	Residential	Other energy	Catering industry
	Cemetery	**Petroleum refineries**	Nutrition	Health care
	Golf course	**Chemical**	**Textile**	Offices & administration
	Zoo & theme parks	**Electricity, heat & natural gas**	**Paper**	Education
	Sports grounds	**Metal industry**	**Livestock farming**	Other services
	Campsites & holiday centres	Waste & waste water	**Arable farming, horticulture**	Independents
	Other recreation	**Mining**	Hunting, forest, fishing	**Other business sites**
	Greenhouses	**Wood industry, manuf. furniture & other and construction industry**	Wholesale trade	**Other agricultural infrastructure**
	Undeveloped artificial sites	**Manufactured products of rubber or plastic and containing other non-metallic mineral products**	**Transport & traffic**	
Level 3	**Commercial airport**	**Mine slag tip**	**Landfill site**	
	Other airports	Quarry	Recreation parks	
Level 4	**Port areas**	**Military areas**		

3.1.2 Agricultural use parcels

Available at geopunt

Overview of parcels in agricultural use on the closing date of the

collective application that year. The inventory also includes pools, wood edges and agricultural production facilities (yards with stables and buildings).
- Department of Agriculture and Fisheries.
- Available on geopunt for the years 2008 to 2017
- shapefile
- 1:2000
- Total areas per cultivation also downloadable in Excel:

https://lv.vlaanderen.be/nl/nieuws/voorlopige-arealen-landbouwteelten-uit-de-verzamelaanvraag-2018

3.1.3 Vito inventory of asbestos roofs

https://emis.vito.be/nl/artikel/asbest-spotten-vanuit-de-lucht
The Vito is currently commissioned by the OVAM on a project to start an asbestos inventory for Flanders via remote sensing techniques. Based on available data it appears that multispectral aerial images (RGB) with a resolution of ten centimetres or better are sufficient to recognize corrugated sheets and slates with acceptable accuracy. We already have such images for all of Flanders. These were collected in an intensive measurement campaign that ran from 2013 to 2015 in the context of Digital Height Model Flanders II. On the basis of this data, a map is compiled indicating where potential asbestos roofs may lie. This map will be combined with the available GIS building databases to determine the year of construction of the buildings concerned. Based on this, it can also be estimated whether the roofing actually contains asbestos.

Vito: Jan Biesemans

3.1.4 Maps of high voltage cables

Maps of the high-voltage grid in Belgium can be downloaded from the websites below. A distinction is made between overhead lines and ground cables. The pylons are also indicated, these are relevant since they can give rise to diffuse soil contamination with zinc.

https://webkaart.hoogspanningsnet.com/index2.php#9/51.0992/4.8105
https://www.hoogspanningsnet.com/netkaarten/actuele-netkaarten/elia/

3.1.5 War Ammunition

The practical guide for unexploded ordnance war ammunition (2016) contains maps of regions in Flanders where the detection of CTE (conventional and toxic explosives), and possibly related lead and copper contamination, is very high.

In general, it can be stated that in the following environments the chance of finding CTE should be considered very high:
- the (sub) municipalities located in the “Destroyed Regions”
- the beaches and dunes of the Flemish coast;
- the dumping sites of ammunition and the disappeared ammunition parks (both on land and in the water);
- the military infrastructure and the (former) military training grounds.

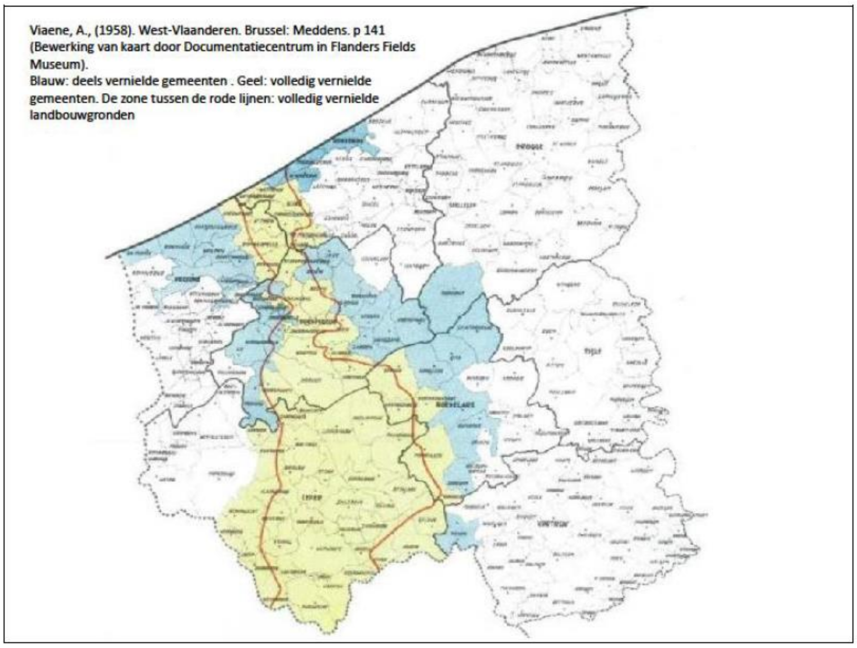


Figure 3-1 : regions in Flanders where the detection of CTE , and possibly related lead and copper contamination, is very high

http://vlac.be/wp-content/uploads/2018/03/Praktische-leidraad-niet-ontplofte-conventionele-oorlogsmunitie-versie_20160209.pdf

Maps are also included in the OVAM study mentioned under Section 2.1.1.2.

3.1.6 Areas of interest

A number of areas of attention are known in Flanders where increased amounts of environmental contaminants occur in the air, soil and/or groundwater. Human biomonitoring campaigns take place in these areas and the VMM monitors air quality (see the previous sections)

This concerns the areas:

- Beerse: At the Schoten-Turnhout canal in Beerse, all kinds of industry (non-ferrous, brickyards, etc.) have been established since the early 20th century. During the production processes, large quantities of environmentally contaminating substances (including heavy metals) were released into the environment. This mainly concerns cadmium and lead.
- Noorderkempen (Balen, Mol, Hamont-Achel, Neerpelt, Overpelt, Lommel)
- Hoboken: non-ferrous companies
- Ghent and the canal zone: This mainly concerns a particulate matter problem, but higher concentrations of PCBs and lindane are also measured in the blood of young people from this area.

3.1.7 Location (old) railway lines, (old) tram network

On the website below, the development of the rail network between 1830 and 2000 can be followed is steps of 5 years. The former and current location of railways in Belgium can be derived from this.
https://www.belrail.be/N/infrastructuur/kaarten.html

Maps are also available for the former tram network. However, not all of these have been digitized. Some Wikipedia pages already bundle several of these maps.
https://nl.wikipedia.org/wiki/Tram_in_Belgi%C3%AB
https://nl.wikipedia.org/wiki/Nationale_Maatschappij_van_Buurtspoorwegen#Sporen_van_het_verleden

3.1.8 STATBEL - NACE codes

On the STATBEL website it is possible to make overviews of companies in Belgium based on the NACE code. The NACE code is a code assigned by the European Union and its Member States to a specific class of commercial or non-commercial economic activity. NACE is therefore an official European list of activity descriptions. The NSSO, the VAT administration and the business counters use these to classify companies into sectors.

This may be relevant in the context of diffuse soil contamination for identifying a number of locations where activities can potentially be a significant source of diffuse contamination.

3.1.9 Power stations

A list of the known power stations in Belgium, the type of fuel and the period is available online (https://nl.wikipedia.org/wiki/Lijst_van_elektriciteitscentrales_in_Belgi%C3%AB). This list is useful for determining regions that may be diffusely contaminated by, for example, coal-fired power stations.

3.1.10 Traffic figures on Flemish inland waterways

Traffic figures on the Flemish inland waters are available at https://www.binnenvaart.be/publicaties/feiten-cijfers. From this it is possible to deduce the busiest routes to determine where diffuse contamination from inland shipping is most likely.

3.2 EMISSIONS

3.2.1 Data Integrated environmental annual report

Certain Flemish companies are obliged to communicate certain environmentally relevant information to the Flemish government via the Integrated Environmental Annual Report (IMJV). The integrated environmental annual report contains an overview of the contaminants that these reporting companies emit. The VMM processes the data for waste water, groundwater and air contamination. As a result, the VMM has an extensive database of contaminants that (reporting) companies emit into the water and air.

- Water part
  A company/organization must fill in the Water part of the IMJV if it is obliged to have an environmental license as class 1 or 2, and also disposes of certain substances in waste water from its company site above a certain threshold. It makes no difference whether the waste water is discharged into surface water, sewerage or discharged to a private water treatment plant.
- Air part
  An operation must fill in the Air part
  - if an environmental permit is required as class 1 or 2, and if, in addition, the total emissions from the entire environmental unit exceed the threshold values for at least one contaminant in the year in question.
  - establishments with a large storage or transhipment capacity for dust-generating substances

Reporting companies submit their reports every year. This concerns approx. 780 companies in Flanders.

The data with emissions into the air and water can be freely downloaded from:
h)ttps://www.vmm.be/data/imjv-databestand .

Via the website https://www.milieuinfo.be/prtr/website/start/start-flow?execution=e3s1 reports can be compiled per parameter or per location. The data is available for every year since 2004.

Data is available for the following parameter groups (for details per parameter group, see the summary matrix).
- Air: CO, SOx, NOx, F-compounds, Cl-compounds H2S, NH3, HCN, CS, methane, non-methane volatile organic compounds (including BTEX and VOCs), ozone-depleting substances and F-gases, semi-volatile organic compounds (including PAHs and PCB), PBB, phthalates, heavy metals, PCDD and PCDF, fine particulate matter.
- Water: inorganic substances, general organic parameters (incl. BOD, COD), BTEX, PAK, Phenols, OCP, other organochlorine compounds (including VOCs), ONP, OFP, organotin compounds, heavy metals, PCDD/PCDF, PCB and brominated diphenyl ethers.

3.2.2 VMM emission-immission reports

The VMM publishes an annual report on emissions into the water and air in Flanders (6).

3.2.2.1 Air

The emissions of the following substance groups relevant for soil are inventoried by the VMM: Heavy metals, PAHs, dioxins, PCBs and HCB. For air, emissions are discussed per sector (industry, energy, building heating, traffic, off-road machines and agriculture and horticulture) and per substance (group). Various data sources and models are used for this:

- the data from the integral annual environmental reports (see Section 1.1)
- for activities whose emissions fall below the threshold value and are therefore not subject to reporting, a generic estimate is made on the basis of the following data:

  - the results of the Flanders energy balance with regard to combustion emissions;
  - specific process emissions: contacts with the relevant federations and/or companies
  - calculation modules and models:
    Developed by TML:
    - The emissions of air contaminants by road traffic are estimated using the software tool COPERT 4v11.4. The main input parameters are:
      - the vehicle fleet,
      - mobility (vehicle kilometre),
      - speeds,
      - fuel specifications and temperatures.
    - Emissions from inland shipping, marine shipping and rail traffic are calculated using the EMMOSS model38. The main input parameters are:
      - number of tonne-kilometres travelled per waterway;
      - percentage of empty shipping per waterway;
      - sulphur percentage in the fuel;
      - age distribution of ship types;
      - speed of the ships;
      - distance (trajectory) from the waterway.
      - For rail traffic: The main input parameter in this model was the number of gross tonne-kilometres travelled by railroad locomotives and railcars for freight and passenger transport

  - OFFREM is used to estimate off-road emissions.
  - The emissions of air contaminants from aviation is estimated using EMMOL.

    Developed by VITO:
    - Inventory of heavy metals
      - Format: delivered at the time in Excel.
      - General. Development of a method for estimating the emissions of heavy metals into the air in Flanders by drawing up a heavy metal emissions calculation model and drawing up a method for the geographical distribution.
      - 15 heavy metals studied: Antimony (Sb), Arsenic (As), Beryllium (Be), Cadmium (Cd), Chromium Total (Cr), Cobalt (Co), Mercury (Hg), Lead (Pb), Copper (Cu), Manganese (Mn) , Nickel (Ni), Selenium (Se), Thallium (Tl), Vanadium (V) and Zinc (Zn).
      - years studied: 2000 and 2005.
      - sectors studied: all sectors.
    - Inventory of collective registration of combustion emissions

> Format: delivered in Access at the time.
> General. Updating and optimizing the existing methodology for estimating the emissions from combustion processes into the air for the collectively registered companies in Flanders based on a completely new emissions calculation model created in Access. The geographical distribution was performed on the basis of a GIS calculation model.
> 26 contaminants were studied and the following 10 contaminants estimated: CO, SOx as SO2, NOx as NO2, hexachlorobenzene, benzo(a)pyrene, benzo(k)fluoranthene, indeno (1,2,3-cd) pyrene, benzo(b)fluoranthene, PCBs, PCDD/F.
> years studied: 2005 and 2008.
> sectors studied: industry and energy.

- Inventory of POPs
  - Format: delivered at the time in Excel.
  - General. Development and optimization of the Flemish emissions inventory air for POPs by creating an emissions calculation model for POPs and a geographical distribution model (EISSA).
  - 34 POPs studied, see the report for the listing: including dioxins, a whole range of PAHs, pesticides, fire retardants, etc.
  - years studied: 1990, 1995, 2000, 2005 and 2010.
  - sectors studied: all sectors (distinction in more than 70 emissions sources)

In addition, the VMM also uses models to estimate the air quality on the basis of the measurement data and the emissions inventory. The following models are used for the parameters relevant to soil:

- The IFDM-EMIAD model (Immission Frequency Distribution Model - Emission, Meteorology, Immission Antwerp Daily) makes it possible to calculate and map the distribution of heavy metals in the vicinity of the Hoboken, Beerse and Genk hotspots with a high resolution.

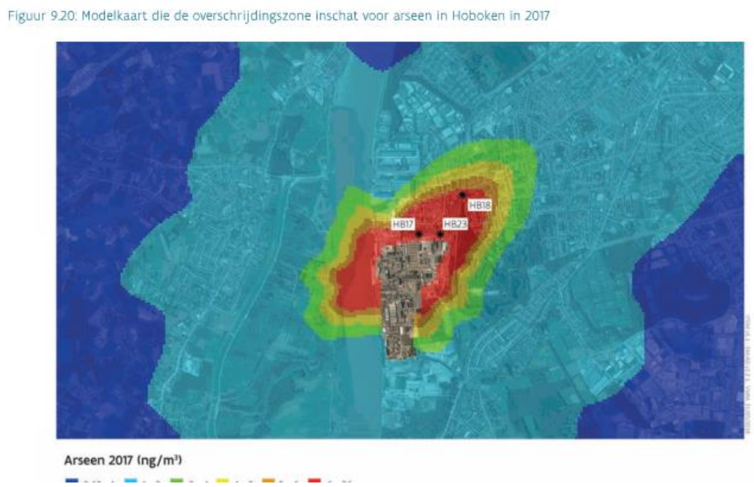


Figure 3-2: modelled map with estimation of the area exceeding treshholds for arsenic around Hoboken (VMM, Jaarrapport lucht, 2017

- The VLOPS model (Flemish Operational Priority Substances model) is an atmospheric transport and dispersion model that calculates air quality and depositions on the basis of emissions data, land use data and meteorological data. The Flemish emissions data comes from the most recent figures from the VMM Air Emissions Inventory. The emissions data for sources outside Flanders come from the EMEP (The European Monitoring and Evaluation Program) and E-PRTR (The European Pollutant Release and Transfer Register) emissions inventories. This model was used to measure the deposition of PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo (k) fluoranthene and indeno (1,2,3-cd) pyrene) and heavy metals (As, Cd, Co, Cr, Cu, Hg, Ni, Pb and Zn). The calculations were calibrated by performing a comparison with the available measurement data (see Section 2.2.4).

3.2.2.2 Water

The VMM also reviews the overview of emissions and immissions into water in each sector (100).

The emissions inventory is drawn up on the basis of the following data sources:

- The waste water monitoring network (see Section 2.2.2.2)
- results of concentration measurements from business campaigns and with the flow rate data that companies report on a voluntary basis. These data are publicly accessible via the VMM Geoloket (see also Section 2.2.2.2)
- reported freights from the IMJV (see Section 3.2.1)
- estimated emissions from the unmeasured industry and diffuse sources via the Weiss model

The WEISS Model

WEISS stands for Water Emission Inventory Support Tool and is an instrument that was developed by the VITO in collaboration with the VMM in the context of a LIFE+ project in the period 2010-2013. Since 2013, the VITO has supported the VMM in further expanding the WEISS tool in terms of functionality and content. WEISS is used within the VMM to gain insight into emissions towards the surface water because of the various emissions sources (households, industry, services, infrastructure, soil, agriculture, traffic, atmospheric deposition, etc.). The emission sources and the associated transport routes into the surface water (run-off, sewerage) are calculated with a very high spatial resolution (100 m).

The data in this VITO study/tool consist of:

- 9 sectors: population, soil erosion, atmospheric deposition, energy, trade & services, industry, infrastructure, agriculture and transport.
- Substances: heavy metals, PAH, nitrogen, phosphorus, organic substances, medicines and plant protection products.
- Years: since 2010 for every year.

The WEISS model maps significant sources and their contribution to water contamination . The emissions are calculated from a bottom-up approach, starting from the detailed location of the source, followed by the calculation of any transport (via run-off or via sewerage) and the ultimate contribution to water contamination.

The gross and net emission maps per sector can be consulted and downloaded for the years 2010-2013 via the WEISS geo portal (from the LIFE project). However, data is available from the VMM until 2017.

The data cannot be used immediately to convert gross emissions into freight and concentrations in soil, since the emissions routes and factors are defined as a function of losses to surface water.

The model works according to the following principle:

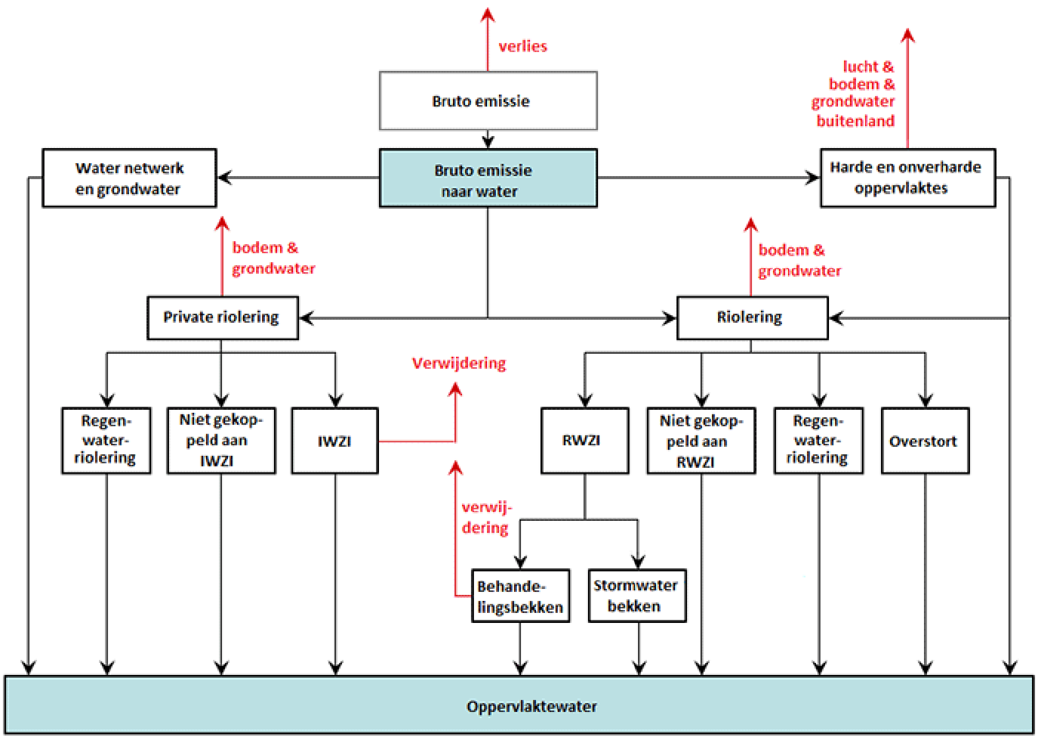


Figure 3-3: diagram of the WEISS-model (weiss.vmm.be)

A gross emissions map is made per substance/source combination, which is a grid map of Flanders and which shows the gross emissions per hectare grid as the amount of the contaminant released at the source. On such a map, the gross emissions are shown where the source is located. The all or part of the emissions released at the source reach the surface water. The sewage treatment plants purify the waste water that is supplied via the sewers and then discharge it into the surface water. Depending on the route that the waste water follows, losses can also occur through infiltration into the soil, through evaporation into the air, through run-off abroad or through sewage leakage.

The net emissions are the part of the gross emissions that actually reach the surface water. The WEISS model calculates a net emissions map for each substance/source combination, which is also a grid map of Flanders and which shows the net emissions per hectare of grid where it ends up in the surface water.

More information about the model can be found at http://weiss.vmm.be/

3.2.3 Emissions from heavy metals in building materials

The VMM and Vito developed a calculation method to estimate the diffuse emission of heavy metals to water as a result of corrosion of building materials (13). 14 metals have been identified that can occur in water drained from buildings: copper, zinc, lead, aluminium, iron, silver, titanium, magnesium, tin, bismuth, antimony, sodium, nickel and chromium. If this water drains into the soil, this can also lead to diffuse soil contamination. Calculations were carried out for Zn, Cu, Pb, Al, Cr and Ni for the water flowing from roof and facade elements. In addition, emissions from galvanized fencing and chicken wire were also taken into account. Based on surveys, aerial photos and the figures from the land register, emissions were then calculated for each building type. Zinc was always the parameter with the highest gross emissions.

	1998			2002			2005		
(g/jaar)	koper	lood	zink	koper	lood	zink	koper	lood	zink
gesloten bebouwing	1,515	4,254	25,729	1,512	4,243	25,648	1,511	4,236	25,599
halfopen bebouwing	1,668	4,154	33,576	1,654	4,131	32,987	1,645	4,118	32,634
open bebouwing	2,437	4,128	41,734	2,430	4,122	40,658	2,426	4,120	40,212
appartementen	1,887	0,757	204,607	1,884	0,806	202,059	1,883	0,830	200,767
handelshuizen	2,524	4,198	54,125	2,522	4,196	53,773	2,521	4,195	53,636
industriële gebouwen	0	25,161	505,587	0	24,716	491,081	0	24,516	484,565
bijgebouwen	0	0,539	9,766	0	0,538	9,615	0	0,537	9,547
andere gebouwen	8,048	0,897	103,886	7,924	0,916	104,653	7,844	0,929	105,176

Figure 3-4: emissions of copper, lead and zinc according ot building type (13).

3.2.4 Emissions from road traffic tyre wear

Commissioned by the Directorate-General for Public Works and Water Management, a calculation method was developed to calculate the emissions of particulate matter, coarse particulate matter, metals, PAH and nonylphenols as a result of tyre wear in the Netherlands (5). This yielded the following figures:

Tabel 16: Emissies naar bodem als gevolg van bandenslijtage, (kg/jaar).

Stof	1990	1995	2000	2005	2010	2013	2014
Antimoonverb. (als Sb)	8.8	8.7	8.4	7.8	7.0	6.6	6.4
Arseenverb. (als As)	8.8	8.7	8.4	7.8	7.0	6.6	6.5
Cadmiumverb. (als Cd)	8.9	8.8	8.5	7.9	7.1	6.7	6.6
Chroomverb. (als Cr)	88	87	84	78	70	66	65
Koperverb. (als Cu)	451	449	436	410	372	356	350
Loodverb. (als Pb)	886	876	845	785	705	668	654
Nikkelverb. (als Ni)	442	437	421	391	351	332	325
Seleenverb. (als Se)	89	88	85	79	71	67	66
Zinkverb. (als Zn)	103 347	102 593	96 772	88 129	78 659	73 575	71 790
Anthraceen	15	15	15	14	13	3.6	2.4
Benzo(a)Anthraceen	46	45	45	43	39	11	7.3
Benzo(a)Pyreen	38	38	37	35	32	9.2	6.0
Benzo(b)Fluorantheen	117	115	114	108	98	28	18
Benzo(ghi)Peryleen	89	88	87	83	75	22	14
Benzo(k)Fluorantheen	65	64	63	60	54	16	10
Chryseen	170	168	166	158	143	41	27
Fenanthreen	77	76	75	72	65	19	12
Fluorantheen	136	134	132	126	114	33	21
Indeno (1,2,3-c,d)Pyreen	14	14	14	13	12	3.4	2.2
Naftaleen	51	50	50	47	43	12	8.1
Nonylfenol/Ethoxylaten(Np/Npe)	177	171	157	66	52	47	45
Grof stof	8 846 183	8 748 078	8 427 543	7 820 772	7 025 444	6 644 213	6 502 101

Figure 3-5: emissions to soil as a result of tyre wear (kg/year) (5).

3.2.5 Emissions from medicines

In 2013, a study commissioned by the VMM was carried out by the study agency Grontmij Nederland B.V. with the aim of adding the most important human medicines in WEISS (47). 25 relevant medicines were selected according to a prioritization method based on the presence of medicines in Flemish effluents and surface water, measurements in the Netherlands, ecotoxicity, degree of removal in WWTPs, representativeness of drug groups, availability of useful sales figures and occurrence in analysis packages. National gross emissions have been determined for these 25 medicines (freight to waste water: amount of medicines emitted per person per year).

Stofnaam	ATC code	Excretiefactor	Terugbetaald Totaal verkoop (g/p/j)	Terugbetaald Bruto emissie (g/p/j)	Ziekenhuizen Totaal verkoop (g/bed/j)	Ziekenhuizen Bruto emissie (g/bed/j)	Niet terugbetaald Totaal verkoop (g/p/j)	Niet terugbetaald Bruto emissie (g/p/j)
Dipryamidol	B01AC07	1,00	0,0079	0,0079	0,2607	0,2607	0,1119	0,1119
Propanolol	C07AA05	0,05	0,2691	0,0135	0,5820	0,0291	0,0046	0,0002
Sotalol	C07AA07	1,00	0,3048	0,3048	0,8065	0,8065	0,0172	0,0172
Metopropol	C07AB02	0,11	0,3038	0,0334	0,6293	0,0692	0,0075	0,0008
Bezafibraat	C10AB02	0,51	0,0101	0,0051	0,0140	0,0071	0,0004	0,0002
Som N groep			**0,8879**	**0,3569**	**2,0318**	**0,9120**	**0,0296**	**0,0184**
17b-Estradiol	G03CA03	0,05	0,0017	0,0001	0,0031	0,0002	0,0004	0,0000
Sulfamethoxazol	J01EE01	0,20	0,0288	0,0058	0,4532	0,0906	0,0021	0,0004
Trimethoprim	J01EE01	0,50	0,0058	0,0029	0,0906	0,0453	0,0004	0,0002
Erythromicine	J01FA01	0,98	0,0185	0,0181	0,6003	0,5883	0,0011	0,0011
Lincomycine	J01FF02	0,16	0,0045	0,0007	0,0181	0,0028	0,0004	0,0001
Som J groep			**0,0575**	**0,0275**	**1,1622**	**0,7270**	**0,0041**	**0,0018**
Diclofenac	M01AB05; M01AB55	0,16	0,4267	0,0683	1,7395	0,2783	0,0293	0,0047
Ibuprofen	M01AE01	0,30	4,0289	1,2087	6,4133	1,9240	3,8982	1,1695
Naproxen	M01AE02	0,07	0,6554	0,0459	1,0149	0,0710	0,0874	0,0061
Ketoprofen	M01AE03	0,18	0,0135	0,0024	0,0132	0,0023	0,0010	0,0002
Som M groep			**5,1245**	**1,3252**	**9,1809**	**2,2757**	**4,0159**	**1,1804**
Tramadol	N02AX02; N02AX52	0,25	0,4788	0,1197	5,6450	1,4112	0,0305	0,0076
Primidon	N03AA03	0,40	0,0378	0,0151	0,2044	0,0817	nvt	nvt
Carbamazepine	N03AF01	0,12	0,5533	0,0664	3,5679	0,4281	0,0238	0,0029
Gabapentine	N03AX12	1,00	0,2319	0,2319	1,2987	1,2987	0,0258	0,0258
Levetiracetam	N03AX14	0,95	0,9322	0,8856	10,2623	9,7492	0,0210	0,0200
Pipamperon	N05AD05	1,00	0,0196	0,0196	0,8343	0,8343	0,0004	0,0004
Clozapine	N05AH02	0,10	0,0197	0,0020	2,0709	0,2071	0,0011	0,0001
Quetiapine	N05AH04	0,10	0,2836	0,0284	10,1463	1,0146	0,0206	0,0021
Venlafaxine	N06AX16	0,07	0,3229	0,0226	2,2407	0,1568	0,0198	0,0014
Som N groep			**2,8798**	**1,3912**	**36,2703**	**15,1818**	**0,1430**	**0,0602**
Som totaal			**8,9594**	**3,1087**	**48,9089**	**19,3573**	**4,3048**	**1,3727**

Figure 3-6: Overview of 25 prioritized medicines for which the total sales and gross emissions for Flanders have been calculated for the reimbursed (pharmacies) medicines, hospitals and "non-reimbursed" medicines. Key figures are also totalled for each medicine group and as a total for all medicines. Numbers highlighted in yellow are relatively high compared to other numbers. (47)

C group: cardiovascular system
J group: antibiotics
M group: muscle and skeletal system
N group: nervous system

3.2.6 Emissions from veterinary antibiotics

In the VMM study of the emissions of veterinary antibiotics into the surface water, it was estimated via a model how much veterinary antibiotics end up in the soil via manure. To determine the amount of manure spread per ha in Flanders, the VMM Fertilization Allocation Model (BAM) was used. This model uses available information regarding manure production, use, transport and storage at farm level on the one hand, and fertilization standards and crops at field level on the other. This provides a reasoned estimate of the amount and type of manure applied to each plot. Results for 2012 were used for the analysis in this report. (41) The gross emissions values were also used to determine the concentration of veterinary antibiotics in the soil. These predicted concentrations in soil are shown in the table below.

Bijlage 1. PEC_{bodem} berekening

	Mestkalveren		Varkens	
	REALISTISCH	WORST-CASE	REALISTISCH	WORST-CASE
	µg kg^{-1}	µg kg^{-1}	µg kg^{-1}	µg kg^{-1}
Doxycycline	1,462	5,729	9,388	64,892
Oxytetracycline	2,147	10,279	0,804	19,679
Tetracycline	0,015	0,088	0,004	0,163
Chloortetracycline	nd	nd	0,005	0,322
Sulfadiazine	0,202	44,272	0,324	8,735
Sulfadoxine	0,001	0,005	0,002	0,070
Sulfamethazine	0,000	0,000	0,000	0,005
Sulfathiazole	nd	nd	nd	nd
Trimethoprim	nd	nd	0,000	0,005
Lincomycine	0,019	0,074	1,102	14,854
Tilmicosine	0,075	0,605	0,038	1,206
Tylosine	0,030	0,266	0,617	30,052
Tulathromycine	nd	nd	0,019	0,381
Gamithromycine	0,000	0,001	0,001	0,055
Tylvalosine	0,003	0,023	0,001	0,016
Flumequine	0,282	2,366	0,145	3,657
Marbofloxacine	0,006	0,020	0,032	0,289
Ciprofloxacine	0,025	0,123	0,002	0,047
Enrofloxacine	0,016	0,085	0,011	0,198
Danofloxacine	0,001	0,004	0,000	0,032
Neomycine	0,327	1,677	nd	nd
Paromomycine	nd	nd	0,004	0,057
Gentamycine	nd	nd	0,002	0,113
Thiamuline	nd	nd	0,043	0,878

Figure 3-7: calculated PEC-values for soil for veterinary anti-biotics 41)

3.2.7 Use of plant protection products

Up to and including 2012, the use (kg/year) of plant protection products in Flanders was estimated on the basis of sales figures from the Federal Public Service Health, Food Chain and Environment Safety (FPS VVVL). This concerns the amount of active substance and not the commercial formulations, which still contain all kinds of auxiliary substances (solvents, wetting agents, fillers, etc.). This method was applied to the period 1990-2010.

Since 2013, the use of plant protection products has been estimated on the basis of the results from the Agricultural Monitoring Network (LMN) of the Department of Agriculture and Fisheries, Monitoring and Study Department (AMS). Within the LMN, commercial interest, technical-economic and environmental data are collected from some 750 Flemish agricultural and horticultural companies. These data are extrapolated on the basis of the agricultural census (General Directorate of Statistics and Economic Information, ADSEI) so that a picture of Flanders can be sketched. Data for non-agricultural applications are determined for individuals based on sales figures obtained through the federal government and for public administrations obtained through the VMM. The new method was applied to the data relating to the operating years 2009 and later.

In the period 1990-2010, sales of plant protection products in Flanders fell by about half. The total use of plant protection products fluctuated in the period 2009 to 2015 around 3 million kg of active substances, the "non-agriculture" proportion fluctuated between 90,000 kg and 320,000 kg, 3-10% of the total consumption in Flanders.

Figures for 1990 to 2008 and 2009 to 2015 are available in Excel via the VMM milieurapport.be website. This Excel only contains the total amounts and is not divided up for each active substance https://www.milieurapport.be/milieuthemas/waterkwaliteit/pesticiden/gebruik-van-gewasbeschermingsmiddelen

Information is available and freely downloadable from 2011 onwards via fytoweb (https://fytoweb.be/nl/reductieplan/waakzaamheid/verkoopgegevens). The confidentiality of the recent data (less than 3 years) is guaranteed by an agreement between the administration (Federal Public Service Public Health, Food Chain and Environment Safety) and the Belgian plant protection products industry association (Phytofar). The data is hidden when fewer than 3 suppliers sell a substance (concealed for all levels of recognition, following a cascade procedure). However, according to the decision of 9 March 2009 by the Federal Appeals Commission for access to environmental information, the integral data are available on request. The sales figures based on the fytoweb figures from 2011 to 2017 fluctuate between 6.5 to 7.5 million kg of active substance (for the whole of Belgium).

Additional figures were requested from fytoweb, which distinguish between the use by private individuals and professionals for the years 2012 to 2017. Garden contractors and, for example, railway companies also fall under the group of professionals. The proportion of private individuals in the total sales amounts to approximately 4% of the total number of kg of active substances.

The table below shows the top 10 active substances sold in 2012 and 2017 to individuals and professional users;

Table 3-3: pesticides most frequently sold to private individuals in 2012 and 2017 (fytoweb)

private individuals 2012		**private individuals 2017**	
active substance	kg	active substance	kg
IRON SULPHATE (anhydrous)	61391	IRON SULPHATE (anhydrous)	109548
GLYPHOSATE	36920	GLYPHOSATE	65156
EDTA DISODIUM	24762	EDTA DISODIUM (Synergist)	30234
PELARGONIC ACID (herbicide/defoaming agent)	10519	PELARGONIC ACID (herbicide/defoaming agent)	20322
METALDEHYDE	5028	METALDEHYDE	7978
MCPA	4585	MCPA	5228
PELARGONIC ACID (herbicide)	2352	2,4-D	4500
DIFLUFENICAN	2308	PELARGONIC ACID (herbicide)	3926

MECOPROP-P	1684	MECOPROP-P	2424
COPPER SULPHATE (expressed as CU)	1565	RAPE OIL (INAC)	2177

Table 3-4: pesticides most frequently sold to professionals in 2012 and 2017 (fytoweb)

professional 2012		professional 2017	
active substance	kg	active substance	kg
MANCOZEBE	924972	MANCOZEBE	805983
GLYPHOSATE	664550	GLYPHOSATE	554139
PARAFFINIC OIL (high sulph., IN)	272592	PARAFFINIC OIL (high sulph., IN)	296687
PROSULFOCARB	236936	CHLORMEQUAT	231728
RAPE OIL ESTERIFIED	216845	RAPE OIL ESTERIFIED	210739
PROPAMOCARB	203213	CAPTAN	207884
CHLORMEQUAT	191848	PROSULFOCARB	193440
METAM-SODIUM	183973	PROPAMOCARB	192576
CAPTAN	183440	SULPHUR	168840
THIRAM	164125	METAMITRON	161741

3.2.8 Emissions from pesticides

Arcadis, Ghent University and VMM (101) as well as the Vito and VMM (102) carried out a study into the quantification and geographic location of the use of plant protection products to determine the emissions into the surface water.

They studied a list of, respectively, 14 and 22 active substances and took into account various transport routes, chemical and biological and physical transformations of the substances, use data, cultivation data, soil type, erosion rate, run-off, proximity to waterwaywaterway.

The first study used data from the agricultural monitoring network for agricultural applications and data about the use of pesticides by municipalities from the registration data in the context of the pesticide reduction decree. From this, a use per hectare per crop (2 crops) and per agricultural region and a use per municipality and per hectare of paved/unpaved area was determined.

The second study refined the method further. Usage maps for Flanders were drawn up for the 22 active substances on the basis of 12 cultivation groups. The agricultural use plot map was used for this (103). Some 700 companies were then questioned about their use of pesticides. This data was combined with data from fytoweb (104)where the recognized products, cultivation applications and recommended doses are listed per active substance. The result was presented to an expert group. The emissions per ha, per relevant active substance per municipality, were calculated from this for 12 cultivation groups. This was corrected to prevent complementary agents.

From this input, the algorithm and model from the study by Arcadis and Ghent University (101) were used to calculate the emissions into the surface water. Account was taken of the

- erosion of the top 3 cm of the soil layer and a theoretical deposition of the plant protection products to the soil is calculated and
- leaching of the plant protection products into the soil/groundwater.

3.2.9 Healthier without *("Zonder is gezonder")*

https://www.zonderisgezonder.be/openbare-diensten/gebruiksgegevens-steden-en-gemeenten
https://www.vmm.be/publicaties/duurzaam-gebruik-pesticiden-2017

Since 2010, public administrations have been required to report their pesticides used annually to the VMM. This reporting is done for each type of pesticide and for each active substance. A report with the results is published annually. This report is freely downloadable in PDF format. The latest version contains the total pesticide use for each municipality in Flanders (40). The details for each active substance and the figures for the Flemish and Federal authorities are not included. This data is also not freely downloadable. It may be available on request from the VMM.

3.2.10 PERSAM data and software tool

The VITO contributes to the PERSAM data and software tool developed by JRC and EFSA with which the presence (concentrations) of crop pesticides in the soil can be estimated. In this tool, the user can enter the annual dose (kg/ha) for a given substance as well as the time between application. Decomposition products of the substance can also be included in the calculation. The model then calculates the concentration of the substances and decomposition products in the soil and pore water. Based on the JRC report "soil threats in Europe" (33), the results of this can only be considered to be rough estimates. This model does not provide information on how high pesticide concentrations in European soils can be after 50 years of application and with different pesticides and decomposition products present as a mixture.

Data model structure: Data on soil, weather and crops - European context
- Maps: EU maps (resolution 1 x 1 km) of soil organic matter, soil pH, soil clay content, 22 agricultural crops
- Climate: Standard values derived for 3 'regulatory zones' Northern, Central and Southern Europe
- Maps are available through the JRC website; EFSA data. The tool can also be downloaded for free.

Contact at Vito: Ingeborg Joris
https://www.efsa.europa.eu/en/efsajournal/pub/4982

3.2.11 Flemish environmental input-output model

The Flemish environmental input-output model was developed in the period 2007-2010, commissioned by the OVAM, VMM and LNE. The Flemish environmental input-output model links the economy and ecology in a scientifically substantiated manner. This makes it a powerful instrument for outlining a sustainable policy at the macro level for the Flemish economy and its sub-sectors. The model gathers all the relevant economic and environmental data. It includes an estimate of emissions into the air, emissions into the water, emissions into the soil, energy use, water use, waste and material use figures.

For the emissions into the soil, only the parameters N, P and crop protection agents were taken into account. This was done by including the full use of plant protection products in agriculture as an emission into the soil. The use of non-agricultural plant protection products and the use of biocides has not been included.

https://www.ovam.be/sites/default/files/Update%20milieu-extensietabellen%20naar%202007.pdf
https://www.ovam.be/het-vlaamse-milieu-input-output-model

3.2.12 Wood stoves

In the context of the Green Deal for domestic wood heating, an action point has been put forward to investigate the possibilities for introducing a registration system for existing and new wood stoves by 2022 at the latest. For new wood stoves, it is possible to work via a registration at the time of sale or via a registration with the home pass. For the existing wood stoves, it will be examined whether a link can be made with any future obligations with regard to the maintenance of wood stoves (or possibly also via the home pass). In anticipation of a thorough picture for the existing stoves and for new stoves, the possibilities are being investigated of obtaining a reliable picture of the composition through a statistically representative survey. This activity is being led by AGORIA CIV.

3.2.13 Vlaams Landmaatschappij – manure database - Municipal statistics

→ online application: https://www.vlm.be/nl/themas/Mestbank/Achtergrond/cijfers-en-studies/gemeentestatistieken_mestbank/Paginas/default.aspx

The application contains information about agricultural and horticultural companies and manure transports. These data are displayed for each municipality from 2007.
In the Company data section you can view these data for each municipality:

- the number of farms
- the number of companies by business type
- the area of agricultural land, crops and fertilization rights
- the number of animals in each animal category
- the total manure production
- the use of manure
- the manure surpluses
- the nutrient emissions allowances
- the fertilizer processing obligation

In the section Transport of animal and other fertilizers, the data is presented for each type of transport document:

- manure disposal document
- arrangements with neighbours
- EWSR document (European Regulation on the Shipment of Waste)

For the origin of the manure, the municipality of origin and the type of company from which the manure comes, are looked at, for example a manure processing company or a collection point for manure. In the destination municipality it is indicated what the manure is intended for: spreading, storage at the headland, a collection point, a manure processing installation, etc.

The data can be consulted for 2007-2014 and can be supplied on request in Excel or Access.

PART 2 - IMPACT

4 ESTIMATE OF QUALITATIVE IMPACT

4.1 APPROACH BASED ON QUALITATIVE CRITERIA

In the following sections a qualitative estimate is made of the impact of diffuse soil contamination. This is based on 3 important criteria:

- Which sources can lead to diffuse soil contamination? Has this already been demonstrated by measurement data?
- Does this affect a large area?
- Which substances are involved and how hazardous are these substances, for example, are these substances toxic, persistent, etc.
- Which receptors may be endangered? Are these sensitive receptors, etc.

For the **sources and substances** identified in part 1, the possible pathways through which they can enter the soil will be examined. The areas where they can end up are referred to as "suspected areas for diffuse soil contamination". It is indicated which **data and measurement data** from part 1 support certain pathways and suspected areas and, if possible, the relative importance of the various pathways is estimated (qualitatively). Known **emissions** data are taken into account.
In order to make a full estimate of the possible risks of diffuse contamination, the **substance properties and effects** of the suspected parameters (toxicity, leachability, persistence, decomposition products, ecological effects, effect as endocrine disruptor, etc. are also taken into account). Relatively little is known about a number of parameters and/or (internationally) there are no standards for soil (or other media), the so-called "new substances with a major impact on the environment" (*emerging contaminants*).

The impact of diffuse soil contamination also ultimately depends on the potential receptors, such as the location in sensitive areas such as, for example, drinking water extraction areas, nature reserves, schools, child care facilities, grounds for producing food for humans or livestock, etc.
The potential **exposure** of these receptors to the diffuse contamination must be estimated or quantified in order to gain insight into the potential risks.

The impact of diffuse contamination depends on the situation. Moreover, in most cases there is too little data available for quantifying the impact. Not enough measurement data are available/made available to make statements about the expected concentrations of all parameters in a certain area. In many cases, it is not even possible to locate the location of suspected areas, nor correctly calculate their area.

Therefore, only a qualitative estimate of the impact is made, to support the setup of priorities. Based on this evaluation, any gaps and possible further actions can then be identified. Some of the applied criteria, such as the expected impacted area or soil concentrations, may be better quantified after further study.

For each identified “suspected area for diffuse soil contamination”, it is indicated for each relevant substance group whether the expected impact is large, moderate or limited. The criteria that are taken into account when making this estimate are listed in Table 4.1. The “impact category” is determined on the basis of at least 2 applicable criteria.

Note that if a certain suspected area can be diffusely contaminated by different sources and/or different substances, the cumulative impact is probably greater than in the case of only 1 diffuse source and/or only 1 specific substance group.

Table 4.1: Criteria used to estimate the impact

Impact category	Criteria			
	Expected soil concentrations	**Area**	**Effects**	**exposure**
Large impact (-)	The **emissions** of the relevant parameter group from the source concerned are high. Based on the available direct and indirect **measurement data**, increased concentrations in the soil cannot be excluded. The following data are used • the data available for emissions into the air and water from the IMJV • the VMM annual reports • known soil data from part 3	The expected area that will be impacted is large, it concerns large contiguous areas or smaller areas that occur throughout Flanders, e.g. • agricultural areas, • port areas • road shoulders, railway embankments, etc. • river banks	Negative (toxicological) **effects** of the relevant parameter (group) on humans and the environment: substances are persistent and have a low toxicological (threshold) value. For example: - substances included in the candidate list of substances of very high concern for authorization under the REACH legislation or regulated under the Stockholm Convention (persistent organic pollutants)	Sensitive receptors can be reached: potential human and ecological **exposure** is high, e.g.: • Residential areas, agricultural areas, nature reserves • Gardens, vegetable gardens
Moderate impact (+-)	Based on the available direct and indirect **measurement data**, increased concentrations in the soil cannot be excluded. The **emissions** of the relevant parameter group by the source concerned are moderate. The followingdata are used • the data available for emissions into the air and water from the IMJV • the VMM annual reports • known soil data from part 3	The expected **area** with a direct impact is moderate. Rather, these are local areas in the immediate vicinity of the source or frequently occurring smaller areas, e.g.: • the wider area surrounding a particular industrial site, • the surroundings of firefighting training areas, etc.) • private gardens, public green areas	Negative (toxicological) **effects** of the relevant parameter (group) on humans and the environment: substances are moderately persistent and have relatively low toxicological (threshold) value	Sensitive receptors can be reached: potential human and ecological **exposure** is moderate. For example: • Public domain, recreation areas
Limited impact **(+)**	Based on the available direct and indirect **measurement data**, limited elevated concentrations in the soil cannot be excluded. The **emissions** of the relevant parameter group by the source concerned are rather limited. The following fata are used • the data available for emissions into the air and water from the IMJV • the VMM annual reports • known soil data from part 3	The expected **area** with a direct impact is limited. Rather, these are local areas in the immediate vicinity of the source, for example: • around fences • high voltage pylons, etc.	Negative (toxicological) **effects** of the relevant parameter (group) on humans and the environment: volatile substances or biodegradable substances or substances with a high toxicological (threshold) value	The potential human and ecological exposure is small, few/limited sensitive receptors. • Industrial areas

4.2 MIGRATION PATHWAYS

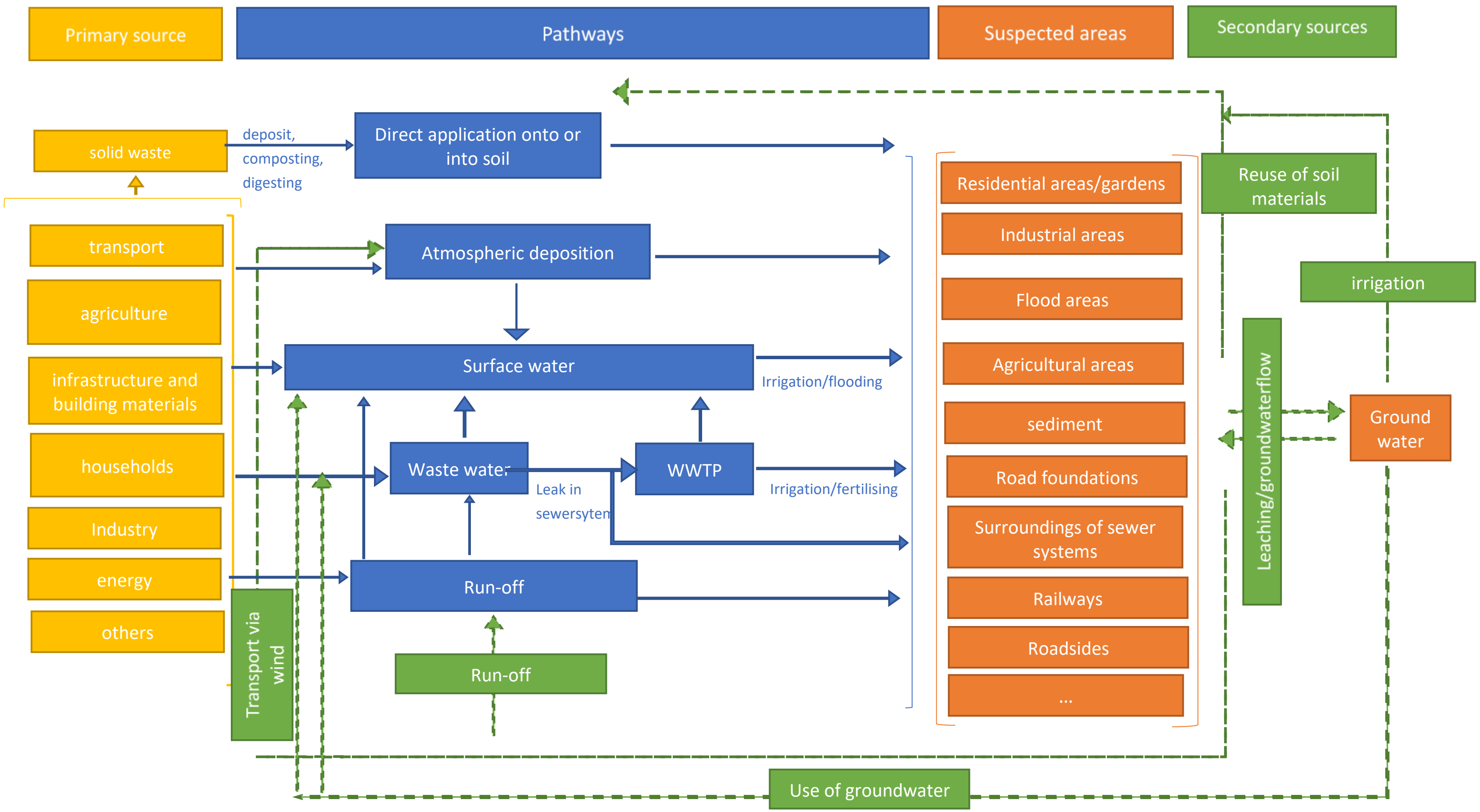
In part 1 of this report many possible sources of diffuse contamination were identified. However, the number of possible migration pathways from the source to the soil is more limited. The pathways can be summarized as atmospheric deposition, (waste) water, run-off or direct application of a substance onto or into the soil. Once the substances have ended up on or in the soil or sediment, they can leach to deeper soil layers or groundwater, or the contaminated soil can be transported by, for example, earthmoving, transport via wind or run-off.

The pathways are summarized in the figure below.

The possible diffuse sources from part 1 are divided into primary and secondary sources.
Primary sources are those through which the contaminating substance is initially released into the environment. To maintain an overview, these were divided into 8 categories: transport, agriculture, infrastructure and building materials, households, industry, energy, waste and others.

In addition to primary sources, there are also secondary sources that can lead to diffuse contamination. By this we mean the further distribution of the contaminants, once they have been released into the environment, for example by reusing soil materials.

Figure 4-0-1: conceptual site model for diffuse contamination



5 IMPACT OF DIFFUSE SOIL CONTAMINATION AS A RESULT OF PRIMARY SOURCES

5.1 TRANSPORTATION

Under the transportation category, we group all sources related to the use and maintenance of roads, cars, trucks, railways, trains, airports and aircraft.
The possible migration pathways are shown in the figure below. Pathways via (waste) water are discussed in Section 5.7.1

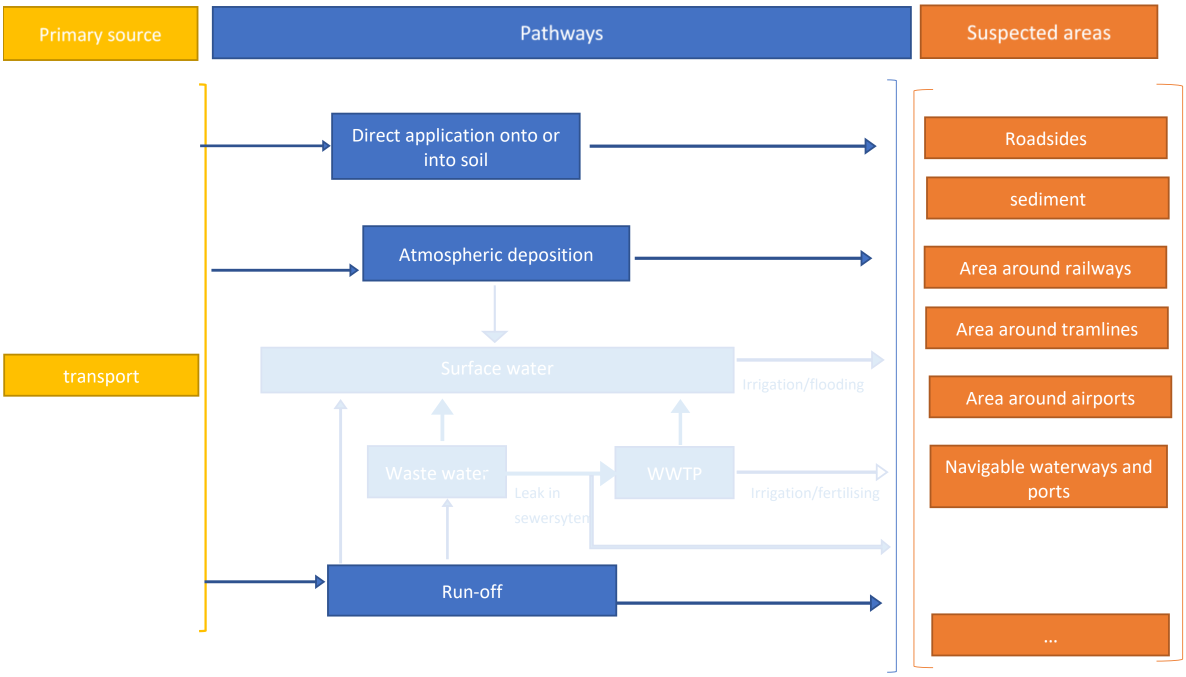


Figure5-1 conceptual site model for transportation

The following suspected areas related to transportation can be identified:

Table 5.1: Summary of the impact of transportation on diffuse soil contamination

Suspected area	Localization Suspected area	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps or uncertainties	Possibilities for supporting evidence of the impact
Area around railways and old railway lines	Belgium has one of the densest and oldest rail networks in Europe. - current railway network: freely consultable via, for example, geopunt.be and via the Flanders spatial model. - the evolution of the railway network (location of old railway lines): can be consulted on the NMBS website	Dense railway network - spread across Flanders - through sensitive lans uses (residential area, agricultural area, etc.)	Heavy metals	Wear parts	Large	- Long-term emissions (oldest rail network in Europe) - Dense rail network, which can affect a large area, - potential sensitive receptors - persistent parameters	Flemish direct measurement data available in TV, not yet digitized	• Rail operator survey • Requesting and analysing data reports on pesticide use by public authorities (2010-2017) • Check whether relevant data are included in the inventory of PCB-containing devices (OVAM) • The total area can be estimated based on the average distance to which contamination along railways can reach due to atmospheric deposition. Further study is necessary for this analysis of impacted land uses • Digitization and analysis of data collected in the context of earthmoving and preparing technical reports, more extensive analysis packages where necessary (screening package)
			PAH	Soot particle emissions	Large		Flemish direct measurement data available in TV, not yet digitized	
				Creosote (sleepers)			No data on number/locations of remaining creosote-treated sleepers in Flanders	
			Pesticides	Maintenance of railways and embankments	Large		No Flemish measurement data Quantities and types of pesticides used	
			PCBs	Electrical installations and cables	Large		No measurement data Determine the location of the main electrical installations, signal boxes and transformers	
			Asbestos	Brakes and friction material, paint in trainsets	Large		No measurement data The link between railways and diffuse asbestos contamination is less often cited in the literature. It is expected that the highest levels will be measured especially at railway stations/in the areas from which the trains brake.	
Area around tram lines	• current tram line network: available on the website of the operator (limited to the cities of Antwerp and Ghent and the coastal tram). • Former tram lines in Flanders, mostly managed by the national society for local railways: maps of the location of these older tram lines exist but must be inventoried.	Often urban areas. Most are on a paved road.	Heavy metals	Wear parts	limited	+ historical tram lines largely disappeared, new tram lines usually more recent. Duration of emissions shorter than for railways. + Mainly urban environment, largely paved around tram tracks. potential affectable area rather small - persistent parameters + in an urban environment: less sensitivereceptors (no agricultural area, nature reserve)	Flemish direct measurement data may be available in the technical report, not yet digitized	• Make an inventory of the location of old tram lines • Use inventory of sleepers in the tram network • Tram network operator survey • Requesting and analysing data reports on pesticide use by public authorities (2010-2017) • Limited sampling campaign to confirm links • Locate unpaved areas around the tram network • Digitization and analysis of data collected in the context of earthmoving and preparing technical reports, more extensive analysis packages where necessary (screening package)
			Pesticides	Maintenance of railways and embankments	limited		No measurement data Quantities and types of pesticides used	
			PAH	Creosote (sleepers)	limited		Flemish direct measurement data may be available in the technical report, not yet digitized. No data on number/locations of creosote-treated sleepers in Flanders	
			PCBs	Electrical installations and cables	limited		Flemish direct measurement data may be available in the technical report, not yet digitized. Location of main electrical installations associated with electrified tram lines	
			Asbestos	Brakes and friction material, paint	limited		No measurement data	

Suspected area	Localization Suspected area	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps or uncertainties	Possibilities for supporting evidence of the impact
Roadsidesand associated trenches	The location of the Flemish roads is known and available digitally. The roads are also included in the Flanders spatial model. However, there does not seem to be a complete inventory of the unpaved roadsides. The trenches along numbered roads (roads managed by the AWV) have been inventoried and are available digitally. Many local trenches are also included in the GRB.	Dense road network - spread across Flanders - through sensitive land use (residential area, agricultural area, etc.)	Heavy metals (mainly lead)	Exhaust gases Leaded petrol (lead) Run off Corrosion of vehicle parts Tyre wear (Zn, Co) Corrosion of galvanized crash barriers (zinc)	Large	Major impact due to run off: - dense road network→ relatively large area affected and large emissions sensitive receptors, unpaved roadsides, impact on soil and sediment - persistent parameters.	Based on experience of technical reports: road shoulders are considered to be suspected soil Impact on sediment: run-off from roads via longitudinal trenches.	• Digitization and analysis of data collected in the context of earthmoving and preparing technical reports. Where necessary, have more extensive analysis packages (screening package) analysed • Analysis of the *"Curieuze Neuzen"* project data/maps project to indicate roads with high traffic pressure and corresponding high diffuse load • Analysis of VMM air quality data maps • Request and analyse road traffic data counts from the traffic centre
			PAH	Exhaust gases Run off tyre wear	Large			
			Mineral oil	Run off Lubricating oils	Large			
			PCBs	Lubricating oil, plasticizer in rubber, seals in cars, asphalt	Large			
			Micro and nanoparticles	Exhaust gases/tyre wear	Large	- Tyre wear is a major source of microplastic	Little literature data, no measurement data	
			PFAS	Lubricants, wax/wax for cars	moderate	- + PFAS were found in car wax in a Nordic council study (105), albeit in low concentrations. Emissions are presumably rather limited	No measurement data	
			PCDD/PCDF	Exhaust gases	limited	+ only limited as a result of incomplete combustion of exhaust gas emissions (traffic approx. 7% of total emissions into the air, see the VMM annual air report)	Little literature data, no measurement data.	
			Asbestos	Wear (including brakes)	Moderate	+ rather limited emissions - potentially higher concentrations of, for example, tunnel ventilation system exhaust - wear: suspected free fibres, major negative effects	No measurement data, is not systematically analysed in the context of earthmoving	
			pesticides	maintenance of the roadsides	Large	Large areas	no Flemish direct measurement data	
Area around airports		Agriculture/habitation	Mineral oil	Lubricants, fuel dump Run off	moderate	+ - Regional impact around the airports	No specific analyses in direct vicinity of (international) airports,	• Analysing data from groundwater/sediment/biota monitoring

Suspected area	Localization Suspected area	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps or uncertainties	Possibilities for supporting evidence of the impact
	The locations of the airports are well known in Flanders and available in the Flanders spatial model. Airports are confined s to a more clearly locatable area. The most commonly used approach and take-off routes are also part of the suspected area and are the main suspected area in terms of diffuse contamination		Asbestos	Brakes, etc.	moderate	- Sensitive receptors (residential areas, etc.) + - greatest impact is expected at the airport site itself (= source contamination, not diffuse), less in the area.	known, few figures known about emissions	networks, are certain parameters found more near airports? • Airport operator survey about pesticide consumption at and around the airport • Analyse results of existing technical reports at and around airports, where necessary have more extensive analysis packages analysed
			PAH	Aircraft combustion engines Run off	moderate			
			Heavy metals	Wear parts Run off Lead in certain aviation fuel	moderate			
			PCBs	Lubricants and coatings	moderate			
			pesticides	Runway maintenance	moderate			
			PFAS	Fire service exercises Run off	moderate			
Navigable waterways and ports	Viewed generally, all navigable waterways can be considered suspected areas. The greatest impact can be expected on the busiest waterways, near the ports and probably also in the vicinity of shipyards.		Heavy metals,	Fuel, wear parts,	Large	+ impact on sediment, multiple sources, large area	Measurement data probably available from waterwaywaterway managers and port companies. Direct or indirect measurement data are available for all these parameters in land and/or sediment (sediment monitoring network, surface water monitoring network). In addition, initiatives are already ongoing for sediment to collect all available information in a sediment explorer. However, it is not easy to determine the contribution from shipping in the measured concentrations since waste water also plays a major role in the existence of diffuse contamination in and around waterwaywaterways	• Analysing and centralizing available measurement data → see. Sediment explorer, flood areas, etc. • Make an inventory of shipyard locations
			mineral oil	lubricants	large			
			PAH	including through the combustion of fossil fuels in engines, coatings on ships and hydraulic infrastructure	Large			
			pesticides	in particular anti-fouling substances such as organotin compounds which must prevent algae growth	Large			
			PCBs	paint and hydraulic fluids	Large			
			PFAS	hydraulic fluids, locks and bridges	Large			

5.2 AGRICULTURE AND LIVESTOCK FARMING

The agriculture category groups the sources related to arable farming, livestock farming and aquaculture.
Aquaculture activities are rather limited in Flanders. If contaminants are released, it is estimated that they will mainly spread via waste water. The main suspected area affected by sources in the agriculture and livestock sector (i.e. due to the use of animal manure, fertilizers and agrochemicals such as pesticides, herbicides and fungicides) is the agricultural land itself.

Agricultural land can also be contaminated with a wide range of parameters by irrigation with surface water containing contaminants or by fertilization with sewage sludge or compost. Agricultural land located in a flood area may also be contaminated by deposited sludge. However, these sources are discussed in Section 5.7.

In addition, contamination present on agricultural land through run-off can spread further to, for example, surface water. However, this is discussed in Section 6.

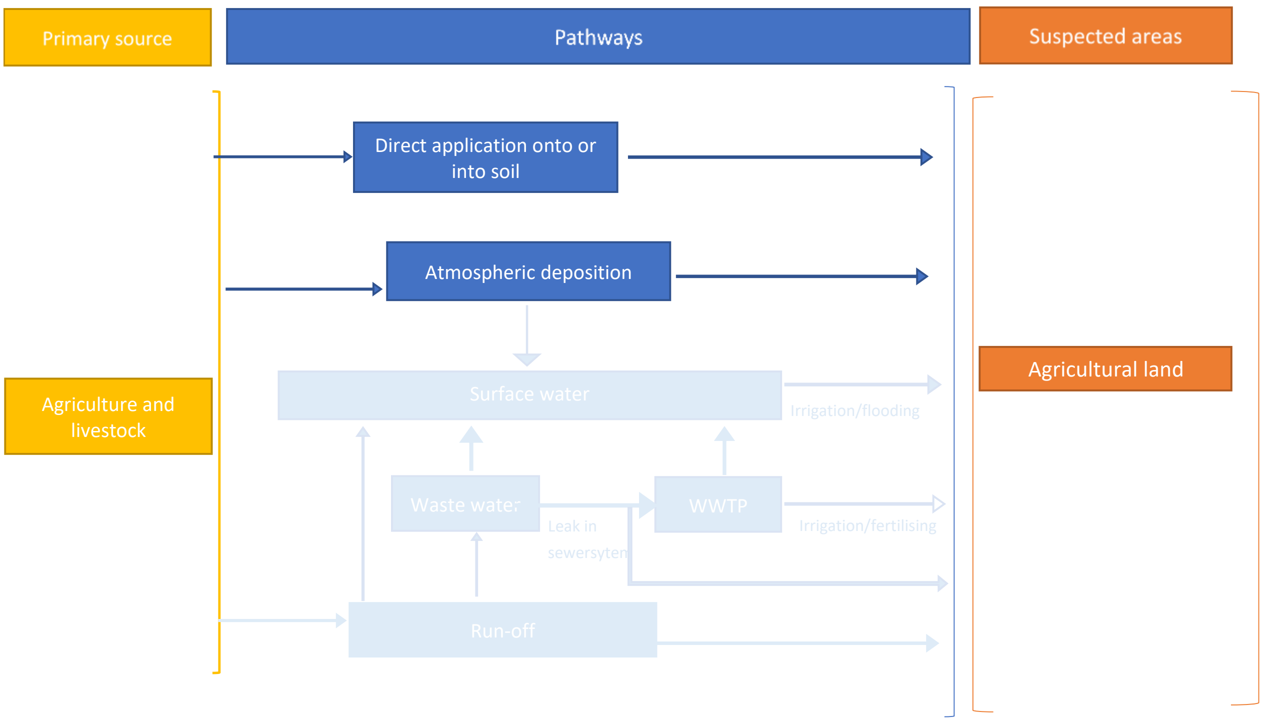


Figure5-2: conceptual site model of the source of agriculture and livestock

Table 5.2: Summary of the impact of agriculture and livestock on diffuse soil contamination

Suspect area	Localization of Suspected area	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps/uncertainties	Possibilities for supporting evidence
Agricultural land	Agricultural areas are known in geopunt and the Flanders spatial model	Agriculture/food/livestock/surface water/sediment	Heavy metals	Direct application of agrochemicals to the soil Animal manure	Large	- Links well documented in the literature. - Very high consumption of agrochemicals in Belgium. - Large area affected. - various heavy metals have negative effects on people and the environment and are persistent - Also impact on sensitive receptors (residential areas alongside agriculture), for example by spray drifting)	No direct Flemish measurement data in soil, but indirect (in manure, waste water, groundwater, surface water, biota, sediment)	• Determination of priority pesticides in soil • Further study into the possible relationship between certain pesticides in soil and crops • Analyses of the indirect measurement data to refine suspect areas and parameters
			pesticides	Direct application of agrochemicals to the soil	Large	See legend (1)	No direct Flemish measurement data in soil, but indirect (waste water, groundwater, surface water, biota, sediment) No standard for soil is available for many pesticides Determine suspected substances based on cultivation of the soil concerned	
			Plasticizers/plastics	Use of foils in agriculture*	limited	+ Rather local, only where foils are used. + Only theoretical link.	No measurement data, very little literature data	
			Radionuclides	Fertilizer	Limited	+ Possible impurity in fertilizer. Very low concentrations expected	Not known where such fertilizer has been used.	
	Greenhouse areas (former), livestock farming, agricultural areas	Agriculture/food/livestock/surface water/sediment	PAH	Greenhouse and stable heating Use of agricultural vehicles (exhaust gases, tyres)	Moderate	+ Local source - Based on the VMM, these sources account for 8% of the total PAH emissions into the air in Flanders.	No knowledge of the location of greenhouses heated with coal or fuel oil, possibly a number of large fuel oil tanks that can be located via GIR	
	agricultural areas	Agriculture/food/livestock/surface water/sediment	PCDD/PCDF	In principle, dioxins can end up on the land as a by-product of chlorinated pesticides	moderate	+ - Only as an impurity in pesticides. low concentrations expected	No measurement data, very little literature data	
	Agricultural areas/livestock farms/pastures	Agriculture/food/livestock/surface water/sediment	PCPP	Animal manure	Large	See (2)	No soil standards available Possible identification of suspected parcels by checking how much	

Suspect area	Localization of Suspected area	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps/uncertainties	Possibilities for supporting evidence
							animal manure has been applied to each parcel. Very large number of substances - need to determine priority substances	
Agricultural land - Haspengouw/fruit growing	Orchard location available in Spatial Model Flanders, fruit cultivation available in agricultural use parcel database	Agriculture/food/livestock/surface water/sediment	Pesticides	Use of pesticides	Large	- Regional problem - At the influents and effluents of the WWTP in Haspengouw, more different and higher concentrations of pesticides are found than in the rest of Flanders. The impact of pesticides on the soil is estimated to be higher here than in the rest of Flanders.	no direct Flemish measurement data in soil, but indirect (waste water)	
		Agriculture/food/livestock/surface water/sediment	copper	Use of copper-containing pesticides	Large	- Various literature data mention the use of copper as a fungicide in fruit cultivation. a greater impact can be expected in the area of fruit cultivation.	no direct Flemish measurement data in soil, a lot of literature data concerning the copper-fruit cultivation link	

* For sources of irrigation with waste water and fertilization with sludge/compost see Section 5.7.

Legend

(1) An analysis of data from the groundwater monitoring network by the VMM from 2010 (39) reports the following conclusions:

- For BAM, a decomposition product of dichlobenil, used in fruit cultivation and for maintenance of gardens and plantations, 3 problem areas were distinguished:
  - South west of West Flanders (no explanation)
  - South east of Ghent (park and recreation area maintenance)
  - Sint-Truiden area (Haspengouw, fruit cultivation)
    However, the thickness of the quaternary package also played a role

- For Bentazon, mainly used in the cultivation of maize, the discovery of these substances in groundwater appeared to be related to the distribution of this cultivation. This was also the case for, among others, dimethylsulfamide (fruit and vegetables), chlorazidone (beets), Isoproturon (grain), metalochlor (maize, beets and chicory)

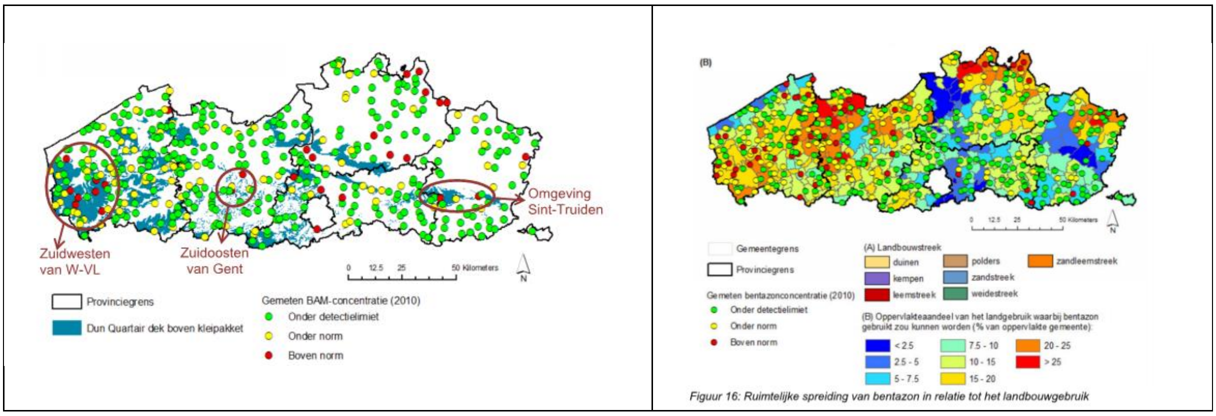


Figure 5-3: left: BAM concentrations in groundwater. Right: spatial distribution of bentazon and relation with agricultural land use. (39)

Less obvious links have been found for other pesticides, possibly because they are more widely used. Moreover, this also always concerns data from the groundwater; the solubility and leachability of the pesticides, the groundwater flow direction and speed also play a role in the measured concentrations. Measurement data in groundwater therefore do not immediately say anything about the situation in soil.

The above data do show that further refinement of the “agricultural land” suspected area for pesticides is possible by examining which crops usually use which products and then on which plots these crops are located. This information can be obtained from the parcel agricultural use database, at least for the period 2008 to the present. This has already been examined in studies by Arcadis and the VITO (see also the source substances matrix, appendix 1). In these studies, the following links were found between crops and active substances:

Aantal bedrijfsplannen	Bentazon	Carbendazim	Chloorpyrifos	Chloortoluron	Chloridazon	Diflufenican	Ethofumesaat	Flufenacet	Glyfosaat	Isoproturon	Lenacil	Linuron	Mancozeb	Mcpa	Metamitron	Methiocarb	Metolachloor	Metribuzin	Oxadiazon	Terbutylazin	Thiram	Tolclofos-Methyl
01=aardappelen			1					2	2			2	2					2				
02=aardbei						1			1					1		1	1		1		2	
03=groenten	1	1	2			1	1		2			1	2	1		2	1		1		2	2
04=appelen		2	1	2		1			2			2	1	2							2	
05=peren		1		2		1			2			2	2	2							2	
06=ander fruit									1			1		1		1					1	
07=graan		1		2		2		1	2	2				2		1						
08=maïs	2							2	2							1	2		1	2		
09=bieten		1			2		2		2		1				2		2					
10=weiden en grasland									2					2					1			
11=sierteelt		2	1			2			2		1	1	2	2		2			2		2	1
12=overige gewassen	1								1					1			1					

Tabel 8. Weerhouden combinaties teelt – actieve stof volgens het aantal observaties (bron: LMN, DLV-AMS)

Figure 5-4: combinations of cultivation – activie substance according to the number of observations (101), (102).

Based on the number of observations, 90 relevant cultivation - active substances combinations are distinguished. The number 2 represents combinations whose importance appears when looking at both the importance of the cultivation groups per active substance and the importance of the substance per cultivation group.

The question arises whether splitting the expected impact per substance per crop makes sense, given that the history of the crops per plot only goes back to 2008. It may be possible to take the cultivation into account for determining suspected substances, e.g. in the context of earthmoving, studies near a maize field can also analyse the package of organo-nitrogen pesticides.

In the third Flemish biomonitoring program too, a link was also found between some pesticides (Dimethyl alkyl phosphates and dialkyl phosphates) and living < 1 km from vegetable cultivation.

Additional support for certain links could also be sought in the data in the surface water and sediment, and biotame measurement networks.

However, given the large number of pesticides and decomposition products, it is necessary to determine which are the most important substances for Flanders to monitor. Various criteria can be used for this (e.g. toxicity, persistence, leachability, quantities used, GUS index, SEQ value, etc.). Moreover, no standards for soil are available for most of the pesticides, which makes it difficult to estimate the impact.

The table below lists which substances are included on the one hand in the POP convention, which were identified as most important in studies by Arcadis and VITO (101), (102) and which substances are included in the OCB package that is typically analysed for suspected soil/sludge samples. This can also be compared with the parameters measured in the various VMM measurement networks (surface water, sediment, biota) as included in the measurement data matrix. This does not give a homogeneous picture. This can be partly explained by the fact that the parameters in each monitoring network and study were chosen according to the purpose of the study. For example, the biotame measurement network mainly measures substances that can potentially bioaccumulate.

Table 5-1: comparison of pesticides included in the POP-convention, the studies performed by Arcadis and VITO (101), (102) and the standard analyses packages for chloride and nitrogen containing pesticides.

Particulate matter	POP	Arcadis study	Vito study	OCB analysis package	ONB analysis package
Atrazine		x			x
Bentazon		x	x		
flufenacet		x			
methiocarb		x	x		
pendimethalin		x			
s-Metalochlor		x	x		
terbutylazin		x	x		x
chlorothalonil,		x			
Deltamethrin		x			
Diflufenican		x	x		
Isoproturon		x	x		
Lambda-cyhalothrin		x			
MCPA		x	x		
Carbendazim			x		
chloropyrifos			x		
Chloridazon			x		
chlorotoluron			x		
Glyphosate			x		
lenacil			x		
Linuron			x		
Mancozeb			x		
Metamitron			x		
oxadiazon			x		
Ethofumesate			x		
Alfa-HCH	X			x	
Gamma-HCH				x	
Beta- HCH	x			x	
o,p-DDE	X			x	
P,p-DDE	X			x	
O,p-DDD	X			x	
O, p – DDT	X			x	
P,p-DDD	X			x	
P,p-DDT	x			x	
Gamma-chlordane	X			x	
Alfa-chlordane	X			x	
Alfa-endosulfan	X			x	
Beta-endosulfan	X			x	
Endosulfan sulphate				x	
Dieldrin	x			x	
Eldrin	x				
aldrin	x			x	
Propazin					x
simazin					x

Particulate matter	POP	Arcadis study	Vito study	OCB analysis package	ONB analysis package
Terbutryn					x
Ametryn					x
cyanazine					x
desmetryn					x
prometryn					x
heptachlor	x				
Hexachlorobutadiene	x				
Hexachlorobenzene	x				
dicofol	x				

In several studies examined in this report, the following substances were identified as the most important:

- Based on the JRC study, the substances most frequently and at the highest concentrations found in the soil were glyphosate, AMPA, DDT and breakdown products and the fungicides boscalid, epoxiconazole and tebucanazole and 1,2,3-trichloropropane (TCP)
- Based on VMM analyses in groundwater: VIS, terbuthylazine, DMS, desethylatrazine, bentazone, BAM, AMPA, Atrazine
- Based on the VMM/Vito study WEISS model: largest gross emissions into the surface water for bentazone, methiocarb, S-methalochlor, terbutylazine, diflufenican, isoproturon, MCPA, carbendazim, chloropyrifos, Chloridazon, chlorotoluron, glyphosate, lenacil, Linuron, Mancozeb, Metamitron, oxadiazon, Ethofumesate
- Based on the Arcadis study WEISS model: largest gross emissions into the surface water for Atrazine, bentazone, flufanecet, methiocarb, pendimethalin, S-matalochlor, terbuthylazine, chlorothalonil, deltametrhin, diflufenican, isoproturon, cyhalothrin MCPA,
- based on recent sales figures; mancozeb, glyphosate, chlormeqat, captan, prosulfocarb, propamocarb, metamitrone

(2) Animal manure
The pharmaceutical products (PCPP) parameter group, like the pesticides, consists of thousands of substances. Here, too, it will be important to determine which are most relevant to Flanders.

Analyses of slurry for antibiotics showed that antibiotics were present in 96% of the fertilizer samples. Calculated antibiotic concentrations in soil (Section 3.2.6) showed concentrations up to worst case several µg/kg. Their impact is therefore estimated to be high. The study took into account an estimate of the amount and type of manure that ended up on each plot. In this way an indication of the most suspected parcels may be made.

As part of the manure action plan, farmers are obliged to analyse soil and manure samples. However, these are only analysed for nitrate, ammonium and phosphate. The analyses are requested via a digital application, after which the results are immediately linked to the relevant plot. If additional parameters were to be analysed here, this could provide useful information in the context of diffuse soil contamination.

5.3 BUILDING MATERIALS/INFRASTRUCTURE

By building materials we mean sources linked to buildings and infrastructure such as gutters, window seals, coatings, tar-containing asphalt, paints, embankments, pipes, electricity pylons, wooden fences and road foundations. The main diffusion pathways into the soil are direct application and run off. Diffusion via water is discussed in Section 5.7.

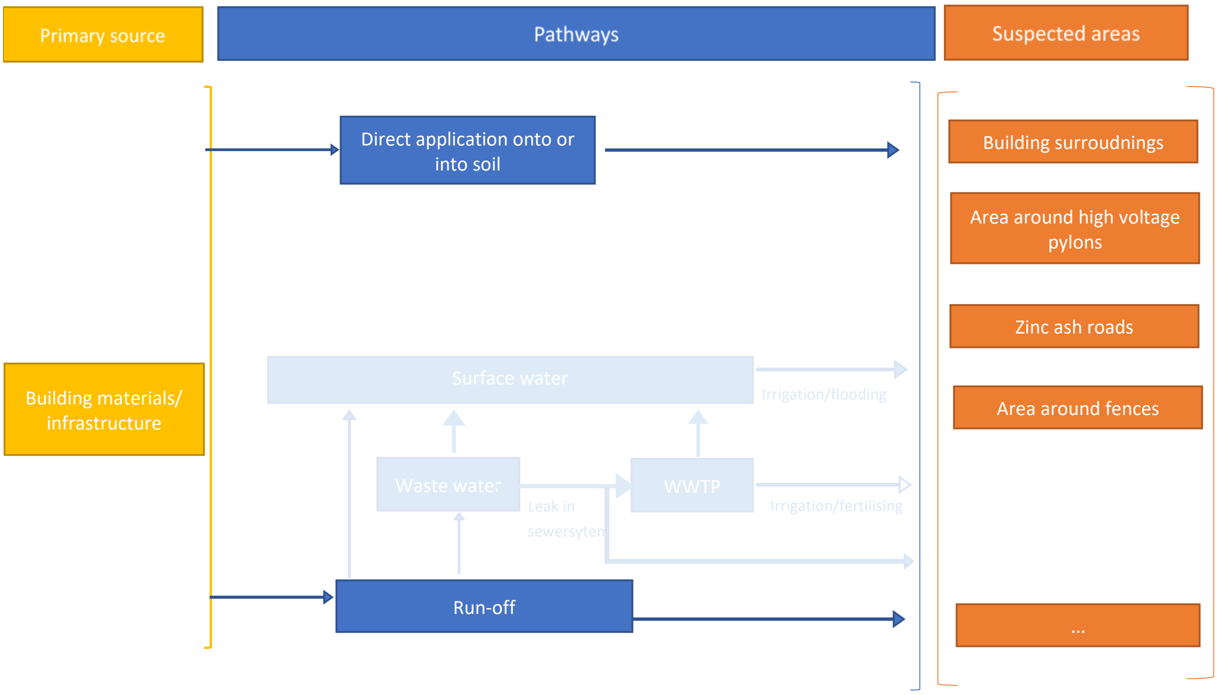


Figure5-5: conceptual site model of the building materials and infrastructure source

Table 5.3: summary of the impact of building materials/infrastructure on diffuse soil contamination

Suspected area	Suspected area location	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps or uncertainties	Possibilities for supporting evidence of the impact
Building surroundings (including homes, gazebos, industrial buildings and sheds, public buildings, signal boxes, etc.)	Spread over Flanders, but rather local in the immediate vicinity of the buildings. Buildings and former buildings can be located (e.g. via the cadaster, aerial photos)	Residential area, industrial area, agricultural area (large stables)	Heavy metals	Paint (lead), gutters (zinc, copper)	Moderate	Multiple references in the literature Flanders covering, but rather a local problem, near the building	Difficult to determine exactly which buildings are suspect. Rather considered Flanders-wide	• Further delineation of suspected buildings based on year of construction. More recent buildings should no longer contain asbestos, lead-based paint or PCBs. • Vito study mapping asbestos roofs • Analysing data "zonder is gezonder"
			PCB	seals	moderate	Multiple references in the literature, concentrations up to 34 mg/kg dw, higher than the proposal for Soil Remediation Standard 10.44 mg/kg dw drawn up by the VITO in 2005 Rather local effect near the building	Difficult to determine exactly which buildings are suspect. Rather consider Flanders-wide	
			Asbestos	Roofs and exterior cladding (slates)	moderate	drip zones - known problems local effect	Difficult to determine exactly which buildings are suspect. Materials containing asbestos have not been inventoried centrally. These are not inventoried for private homes.	
			Plasticizers	Plastic joinery and roofing	Limited	Theoretical link, emissions from plasticizers are estimated to be low	Difficult to determine exactly which buildings are suspect. No measurement data	
			Flame retardants	Plastic joinery and roofing	limited	Theoretical link, emissions for flame retardants are estimated to be low	Difficult to determine exactly which buildings are suspect. No measurement data	
Vicinity of solar cells	Installations registered with the grid operator	Immediate vicinity of solar cells	metal/metal nanoparticles	Run-off/weathering of solar panels	limited	Not yet certain if there is an impact If there is an impact: rather local.	very little measurement data, no link confirmation for the heavy metals.	/
Area around high voltage pylons	limited to the immediate vicinity of the mast. Locations of most masts are known.	Flanders	Zinc	High voltage pylon	Moderate	Literature data range from 200 to 17,400 mg/kg. Across Flanders, but rather local at the pylons.	Measurement data in literature are quite old (1980s).	/
Area around fences	It is very difficult to indicate a suspected area for this. Expected influence very local	Especially in agriculture and residential area (gardens)	Heavy metals	Metal or galvanized fences	limited	Across Flanders, but expected impact very local at the posts/fence	Difficult to locate	/
			PAH	treated wood fences	Limited			
			PCDD/PCDF		Limited			
Zinc ash roads	BeNeKempen overview - however not complete, mainly Kempen region. No high resolution version of the map available	Dense road network through sensitive land use (residential area, agricultural area, etc.)	Heavy metals	Foundation of roads/garden paths	Moderate	The use of zinc ash locally leads to greatly increased concentrations of heavy metals in the underlying soil. The impact is therefore estimated to be moderate. Regional problems in the Kempen region.	Difficult to locate. Not all locations where zinc ashes have been used are known.	• Map of known zinc ash roads from the benekempen project: available in higher resolution? -> share via geopunt, for example?
Foundations of roads and driveways	Spread all over Flanders	road network through sensitive land use (residential area, agricultural area, etc.)	Radionuclides	Concrete and stabilized sand improved with fly ash	Limited	The expected concentrations of fly ash are low. Usage is more likely to be local.	Difficult to locate	/
	Asbestos region		Asbestos	Use of asbestos waste in this region as foundation material for roads and driveways	Large			• Remediation program already ongoing in this region. • Disclosure of data from technical reports

Suspected area	Suspected area location	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps or uncertainties	Possibilities for supporting evidence of the impact
(injudicious) application of recycled construction and demolition waste	Spread all over Flanders	Mainly in inhabited areas	All of the above	If construction and demolition waste has been/is being reused, the polluting substances from this building material can be spread further via this pathway	Large	- the data from technical reports related to earthmoving shows that this often gives rise to increased concentrations in the soil - + The area affected is potentially large. - more sensitive areas such as residential areas are also affected	Difficult to locate where construction and demolition waste has been used in the past Selective demolition, quality control and traceability of the debris to be reused can tackle this problem if all relevant parameters are considered.	

5.4 HOUSEHOLDS AND SERVICES

Under the household category, we group the sources related to the private use of pesticides, (plastic) utensils, electrical appliances, medicines and personal care products. The heating of residential buildings is included in this category. The maintenance of public green areas, such as in city parks, cemeteries, sports fields, etc. was also included in this category. Just like some other services that are not covered by industry, such as crematoriums and firefighting areas

Many of these substances will reach the environment and the soil mainly via waste and waste water. Waste and waste water are discussed further in Section 5.7.

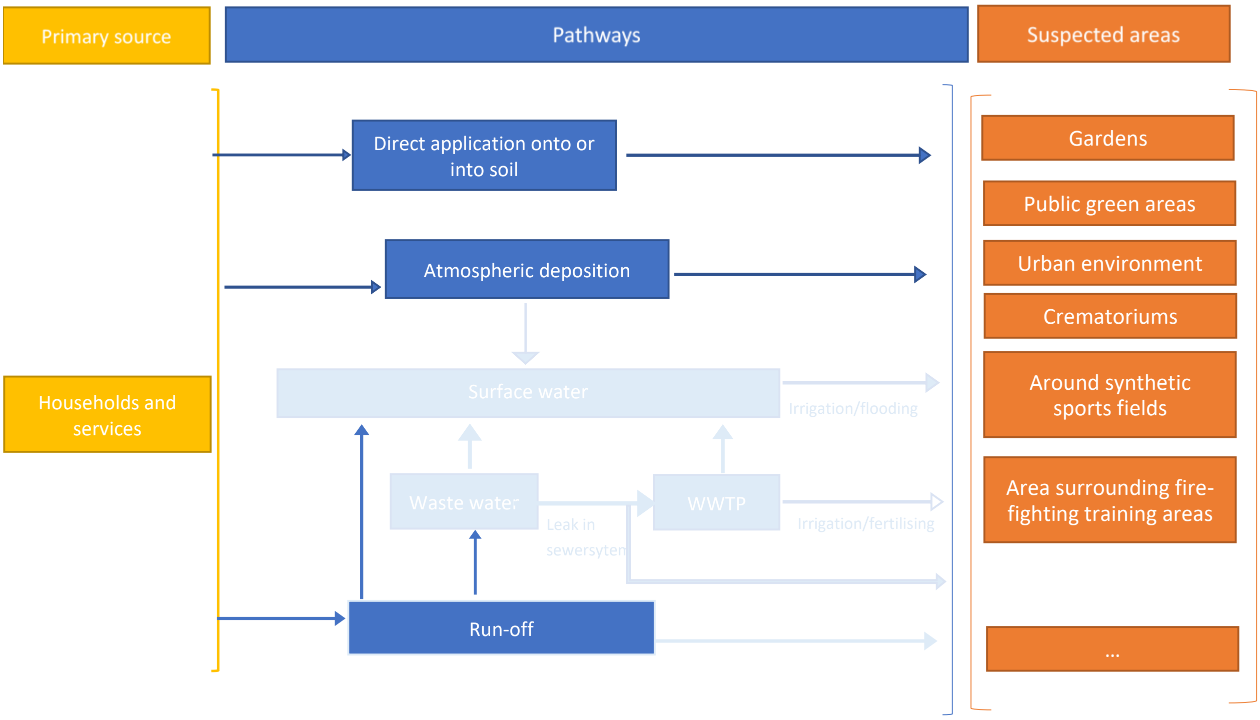


Figure5-6: conceptual site model of the households and services source

Table 5.4: Summary of the impact of households and services on diffuse soil contamination

Suspected area	Suspected area location	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps/uncertainties	Possibilities for supporting evidence oif the impact
Gardens and public green areas	Via the Flanders spatial model	Residential areas, cemeteries, parks, playgrounds	Pesticides	Garden and green maintenance	Large	- Indirect groundwater and biota measurement data (including SOS Mezen, VMM pesticides in groundwater study) - Gardens: sensitive receptor	no direct measurement data, No standard for soil is available for many pesticides Determine suspected substances based on sales to private individuals	• Analyse fytoweb data related to sales to private individuals • Does not include garden contractor data • Only available from 2012
Gardens	Via the Flanders spatial model	residential areas	Heavy metals (Cu)	Growing fruit and vegetables in gardens	moderate	- Gardens: sensitive receptor + rather local, only in gardens where fruit and vegetables are grown -potential high exposure of a limited group of people	few direct measurement data, possibly in healthy from your own soil database Difficult to locate	• "Healthy from your own soil" (gezond uit eigen grond") data analysis
		residential areas	PAHs Heavy metals PCDD/PCDF Radionuclides	Coal ash from coal stoves,	limited limited limited limited	+ Only for older buildings that where heated with coal in the past and where the ashes ended up in the garden. Rather local.	Difficult to locate	• Check the age of houses (cadaster?) or based on historical maps. • Analyse the "healthy from your own soil" data
Urban environment	Spread over Flanders	Mainly residential areas	ZM PAH PCDD/PCDF Nanoparticles (particulate matter)	Heating of houses with fossil fuels and wood, open fire in gardens (barbecue, burning waste, etc.)	Large Large Large Large	- Air emission figures: households largest proportion of emissions of PCBs, dioxins and PAHs. Influence on a large area.	Greater impact expected in densely populated/densely built-up areas.	• Locate densely populated/densely built-up areas (spatialmodel?) • Analyse available measurement data (e.g. groundwater monitoring networks, partly in built-up areas)
Around synthetic sports fields*	Location of sports fields known in the Flanders spatiale model. the synthetic fields are known in the Flanders sports database.	Recreation and residential areas	PAH ZM Plastic/plasticizers	Leaching (recycled) rubber granulates	limited limited limited	+ Rather local impact		/
crematoriums	Find out location of crematoriums via NACE code	Potentially sensitive land use depending on location	PCDD/PCDF	flue gases	moderate	+ Limited number of crematoriums in Flanders + More recent equipped with smoke scrubbers - persistent toxic components + - local impact around the crematoriums	No measurement data	/
Area surrounding fire-fighting training areas**	Difficult to locate, possibly via a survey of fire service areas.	Potentially sensitive land use depending on location	PFAS	fire extinguishing foams	moderate	+ Limited number of sites, rather local impact around the sites - Persistent and toxic substances - Large emissions in these areas	Difficult to locate, also training areas within companies Limited amount of measurement data available	/

* the plot with the synthetic sports field itself is regarded as a "source plot", not as diffuse contamination. The further spreading of rubber particles into the environment and leaching into the groundwater is considered to be diffuse.

** the fire service training area itself is regarded as a single source plot. The wider environment as diffuse contaminated

5.5 INDUSTRY

Industrial activities can emit a wide variety ofsubstances into the environment. Atmospheric deposition   and waste and waste water are estimated to be the main pathways of diffusion into the soil. Waste and waste water are discussed further in Section 5.7.

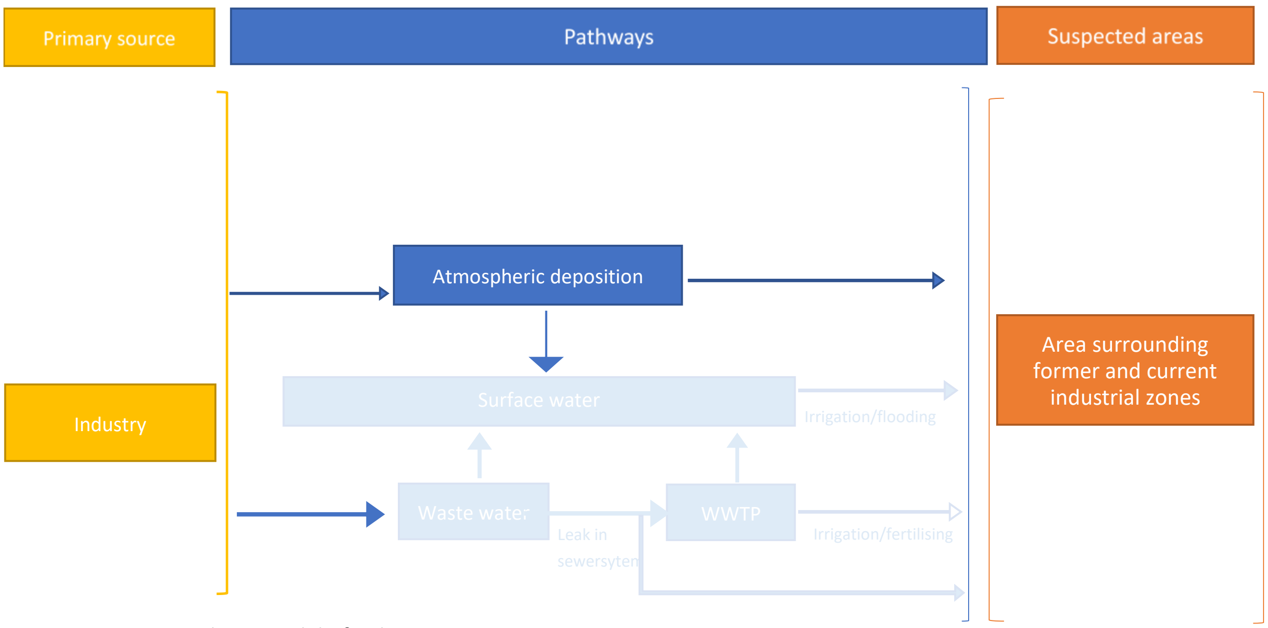


Figure5-7: conceptual site model of industry impact

The area around industrial zones can be considered to be a suspected area for diffuse contamination. A distinction could be made here according to the type of activities, such as, for example, the metal industry in the Kempen region, textile industry, etc. to refine the suspected parameters. For recent activities, this could be done on the basis of the IMJV. After all, for each company (subject to reporting obligation) it is indicated exactly how much of each substance was emitted into the air and at which location (since 2004). Another option for locating suspected areas around certain (more recent) industrial activities is to use the NACE codes and the statistical companies register (CBE). To get an idea of the historical emissions, data from the land information register and the municipal inventory can be looked at. An estimate could be made of which activities, that emit into the air, correspond to which VLAREBO sections. Based on this, suspected source plots can then be identified using the municipal inventory of risk activities. The duration of the activities (also included in the municipal inventory) can also be taken into account in order to determine where a greater impact is expected.

Presumably, the diffuse contamination due to atmospheric deposition will mainly be located to the north-east of the industrial areas, since the predominant wind direction in Flanders is south-west. This was also evident from studies of the non-ferrous industry in the Kempen region.

Industrial areas also generate a lot of traffic. The points discussed in Section 2.1 therefore also apply here. Port areas in particular can be considered suspect. After all, road traffic, shipping, heavy industry, heated offices and buildings and people (sanitary waste water) are highly concentrated here.

A number of industrial sectors have already been specifically mentioned in part 1 of this study. These are included separately in the table. This table should not be considered exhaustive, in general it can be stated that in a certain perimeter around the industrial zone a higher load of diffuse soil contamination cannot be excluded, often due to a combination of industrial activities and busier transport/truck traffic.

Table 5.5: summary of the impact of industry on diffuse soil contamination

Suspected area	Suspected area location	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps/uncertainties/refinements	Possibilities for supporting evidence of the impact
Industry environment in general**	Current industrial areas are known. atmospheric deposition: mainly north-east of industrial areas	Through atmospheric deposition and sediment: all of Flanders	All	Emissions into the air and water*	Large	Large contaminant loads, indirect measurement data (air, water)	Refine suspected parameters and impact by type of industry	• For recent companies: analysis of the data in the IMJV • Historical activities: makea link between the type of industry and the VLAREM section: determining the location of a certain type of industry in the past based on the municipal inventory
Area around metal industry	IMJV/NACE codes/municipal inventory The problem is known and has already been mapped specifically in the Kempen region.	Potentially different land use (residential area, agricultural area, nature reserve, etc.)	Heavy metals	Emissions into the air and water	Large	- See earthmoving studies in the Kempen region - Large amounts of emissions - Long period	Data known in the IMJV	• For recent companies: analysis of the data in the IMJV • Historical activities: making a link between the type of industry and the VLAREM section: determining the location of a certain type of industry in the past based on the municipal inventory
			PCDD/PCDF	Emissions into the air and water	Moderate	+ Smaller contaminant load than for heavy metals - higher toxicity than heavy metals	Data known in the IMJV	
Area around galvanization	via IMJV/NACE codes/municipal inventory		PFAS	Emissions into the air and water	moderate	Theoretical link. - Persistent substances, substance of concern under REACH + Local use on dispersed sites (small area) - But locally high emissions + - exposure mainly in industrial environments	No data in the IMJV	• make a link between the type of industry and the VLAREM category: based on the municipal inventory, determine the location of certain types of industry in the past
Area around scrap processing	via IMJV/NACE codes/municipal inventory		PCB PCDD/PCDF	Emissions into the air and water	moderate	- VMM deposition measurements + The PCB values decrease with increasing distance from the scrap yard, rather locally round operation - If there is habitation, the Agency for Care and Health advises not to eat eggs from free-range chickens	Limited amount of soil data available	• Perform soil analysis at the VMM deposition measurement locations: check soil concentrations as a result of the measured depositions • For recent companies: analysis of the data in the IMJV • history: making a link between the type of industry and the VLAREM section: determining the location of a certain type of industry in the past based on the municipal inventory • analysis of VMM emissions data
Area around textile industry	Textile industry in East and West Flanders. Via IMJV/NACE codes/municipal inventory		Flame retardants	Emissions into the air and water	Large	- Measurements of brominated flame retardants in eel show that high to very high values were measured in the Leie and Scheldt. These may be related to the textile industry concentrated in these regions, mainly around Kortrijk and Ghent. - Persistent and toxic substances	No standards No direct measurement data, but indirect (biota and sediment)	• For recent companies: analysis of the data in the IMJV • history: making a link between the type of industry and the VLAREM section: determining the location of a certain type of industry in the past based on the municipal inventory • analysis of emissions data (VMM)
			PFAS	Emissions into the air and water	Large	- From the measurements of PFOS in the biotame measurement network,	Not in the IMJV No standards	

Suspected area	Suspected area location	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps/uncertainties/refinements	Possibilities for supporting evidence of the impact
						the highest concentrations of PFOS were also measured in the Ghent-Terneuzen canal, Ghent-Ostend, the Yser and the Zeeschelde. These may also be related to the textile industry, although the impact was not confirmed in the exploratory study on PFAS conducted for the OVAM Persistent and toxic substances	Little measurement data	
Area around paper industry	Via IMJV/NACE codes/municipal inventory		PCDD/PCDF	chlorinating of phenol components in wood. Discharged via waste water and sludge	moderate	Rather locally around paper mills	Data known in the IMJV	• For recent companies: analysis of the data in the IMJV • historical activities: making a link between the type of industry and the VLAREM section: determining the location of a certain type of industry in the past based on the municipal inventory • analysis of emissions data (VMM)
			PFAS	production of water and greaseproof paper	moderate	not in the IMJV no standards Little measurement data (there is for biota) Rather local around paper mills*	No data in the IMJV	
Area around chipboard industry	Via IMJV/NACE codes/municipal inventory		PCDD/F	Emissions into the air	moderate	IMJV and VMM deposition monitoring network data. Households are a more important source	No clear link in the literature. No direct measurement data	
Area around (petro)chemical industry	• the 4 refineries in Flanders were located in the Antwerp port area (6) • IMJV/NACE codes/municipal inventory		Heavy metals	Depending on the production process	Large	High emissions	Data in the IMJV	
			PCDD/PCDF	Production of chlorinated compounds	moderate	Limited number of sites Persistent parameter	In the IMJV	
			PAH	Depending on the production process	moderate	Moderate emissions	In the IMJV	
			Flame retardants	Production of plastic	Moderate	Limited number of sites	Hardly reported in the IMJV.	
			plasticizers	Production of plastic	Moderate	Limited number of sites	In the IMJV	
			PFAS	Production sites PFAS	Moderate	Limited number of sites	not in the IMJV no standards Little measurement data (there is for biota)	
Area around asbestos-processing industry	Area around asbestos processing companies	Mainly home driveways, road foundations.	Asbestos	Processing in filler and levelling layers	Large	Well known problem Toxic and persistent component	/	• Policy already worked out (official remediation)
Area around mining	The locations of the mine slag tips are included in the Flanders spatial model	Building materials, nature reserves	Heavy metals	wind and reuse of material in mine slag tips	limited	The locations of the mine slag tips are known. Some have now been transformed into a nature reserve. The minestone may also have been spread around the immediate vicinity of the old mining sites. Rather local impact	A raw material declaration is required for use as a building material. The spread of contamination along this pathway should therefore be limited. Minestone is not always recognized when conducting studies within the context of reusing soil materials	• /
			PCB		limited			
			PAH		limited			

* for emissions from industry via waste and waste water, see Section 5.7

** contamination on the site with industrial activities is considered to be a point contamination. The wider surroundings of an industrial area, where the contamination can no longer be clearly linked to one specific company, as diffuse contamination

5.6 ENERGY

This section discusses the sources of electricity generation from the combustion of fossil fuels, solar panels and electrical installations.

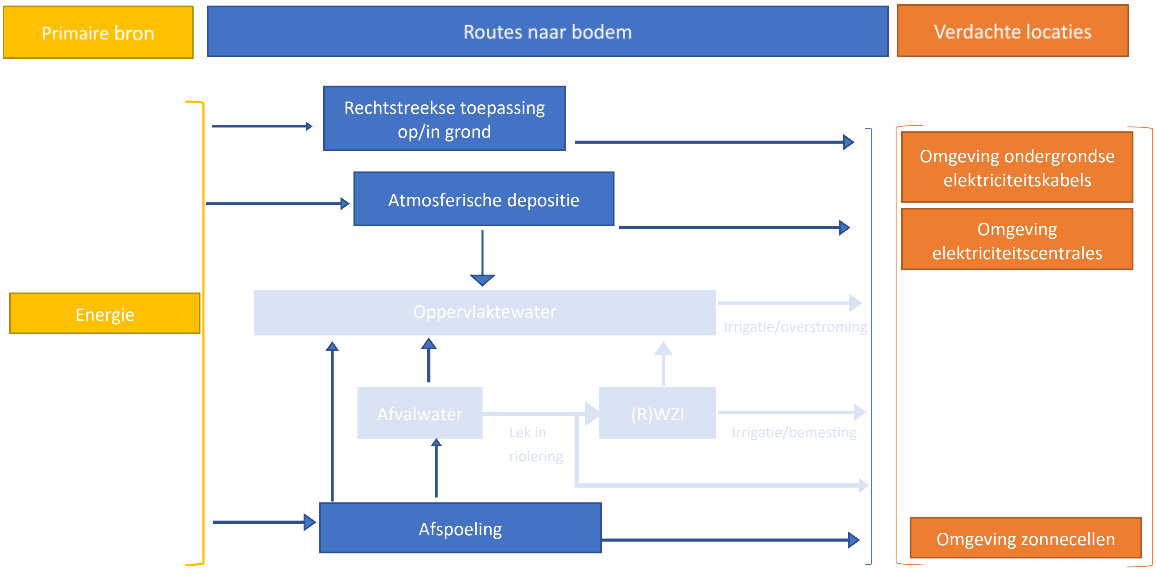


Figure5-8: conceptual site model of energy sources

Table 5.6: Summary of the impact of energy on diffuse soil contamination

Suspected area	Suspected area location	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps or uncertainties	Possibilities for supporting evidence of the impact
Area around power stations using fossil fuels	locations of (former) power stations are known*	Potentially different land use (residential area, agricultural area, etc.)	heavy metals,	Smoke and fly ash. Fly ash used as a soil improver or in cement and concrete.	moderate	theoretical link	no analysis of measurement data has been carried out yet to confirm this	• Analysis data from existing monitoring networks. • Analysis of future earthmoving data in these areas
			PAHs		moderate	theoretical link		
			PCDD/PCDF		moderate	theoretical link		
			radionuclides		limited	+ Raw material declaration required for reuse. Low levels of radioactivity expected	/	/
Area around underground electricity cables	Location of cables known to network operators, partly also available online	Immediate vicinity of the cables, groundwater	Mineral oil	Leaking underground cables	limited	+ Potentially large area but cables themselves very limited in size, underground, theoretical link	no confirmation by measurement data	/
			PCB		limited			

* Large quantities of fly ash from coal-fired power stations were dumped. The fly ash in landfills is discussed further in Section 6.

5.7 WASTE

Sources related to waste and waste water are discussed in this section. Virtually all primary sources generate waste and waste water. Both waste and waste water can therefore contain all of the parameters discussed.

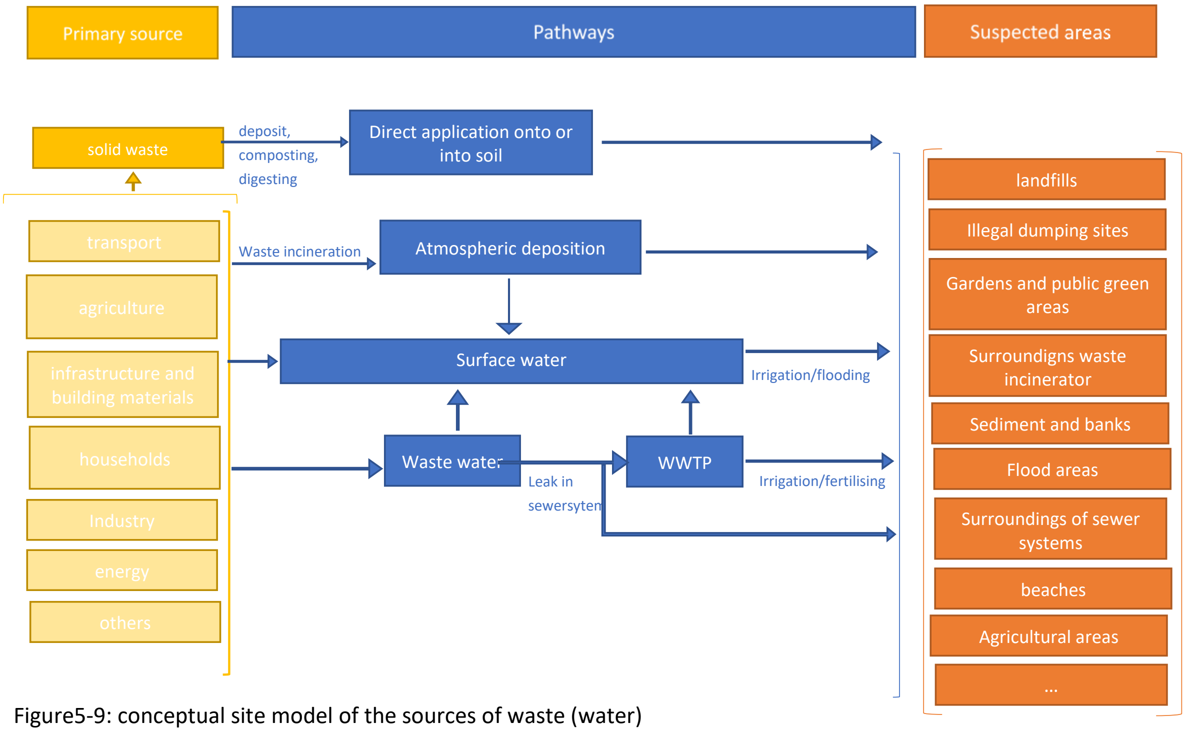


Figure5-9: conceptual site model of the sources of waste (water)

5.7.1 Waste water

Domestic or industrial waste water is cited in many literature sources as a source of diffuse contamination.

Substances present in the waste water can spread to the soil in various ways:

1. Directly through leaking sewers
2. Via waterways
3. Via irrigation with waste water, effluent or fertilization with sewage sludge
4. Contaminants can also “wash up” on the soil. This phenomenon is mainly known for plastics on beaches (“beaching”)

All parameter groups discussed in this report can occur in (waste) water, either through direct discharges, through discharges via water treatment, through run-off or through atmospheric deposition.

1. **Suspected areas around sewers**
   Leaking sewers are a possible source of diffuse soil contamination. The suspected area then concerns the immediate vicinity of these sewers. In contrast to most other suspected areas, the top layer is therefore not suspect here, but rather the layer just below the sewers concerned.

2 **Suspected areas: waterways and flood areas**

3 Once a substance has ended up in waste water, it can move to the waterways either via direct discharges, via overflows or after purification via a (W)WTP. Once the substances are present in the waterway, they can end up in the sediment. In the event of flooding, they can spread from the surface water and the sediment to the soil. During dredging and clearance work, these substances can also spread further, to the banks if the sludge is deposited here or to other locations if the sludge is reused (see secondary sources).

We can therefore consider the sediments, banks and flood areas in Flanders to be suspected areas.

4 **Suspected area: agricultural land**

Irrigation with surface water, waste water, effluent or fertilization with sewage sludge can spread contaminants to agricultural land. In Flanders, all sludge from waste water treatment plants in Flanders is currently incinerated. Sludge from treatment plants for domestic and/or urban and/or industrial waste water can be used in agriculture under certain conditions.

- Specifically for sewage sludge, a raw material declaration is always required at regional level. To be used as a soil improver, the sewage sludge must meet the standards imposed in the VLAREMA for heavy metals, PAHs, PCB, mineral oil, 1,2,3,4-tetrachlorobenzene, pentachlorobenzene and hexachlorobenzene. Until 2018, standards were also included for BTEXs, chlorobenzenes and VOCs.
- In order to deposit it on third-party grounds in Belgium, the federal government must also grant permission for the production unit. The sludge must have an agricultural value. When applying for this authorization, analysis reports must be added on the parameters of heavy metals and PCBs in the case of sludge from surface water softening, sludge from the paper industry, sludge from tanneries or sludge from WWTPs.

A raw material declaration is also necessary for the use of treated waste water for irrigation. An analysis must be submitted of all the parameters required in the permit of the company that produces the waste water. When assessing the application, a risk evaluation is made in response to the intended use of the waste water.

In the past, this was less strictly regulated. Based on the 2011-2012 biomass inventory (OVAM), 1/3 of the sludge production from the water purification plants of food industry was then sold directly to agriculture. In 2008 this was 50%. A part was fermented, after which the digestate also ended up on agricultural land in Flanders. In addition, sludge from the food industry in France and the Netherlands was also processed in Flemish installations. 60% of the waste water treatment sludge from the paper industry went to agriculture.

The sludge from waste water treatment plants has only been completely incinerated since 2006/2007.

1 **Suspected area: Beaches**

Contaminants that have ended up in surface water eventually end up in the sea. From here they can wash up on beaches. This is a known problem especially for (micro)plastics.

5.7.2 Compost and digestate

Compost and digestate from digesters may still contain residues of contaminants, such as PFAS, for example from waste from paper and cardboard factories and plastic. The suspected area therefore includes all land where compost and digestate was used, such as agricultural land, gardens and public green areas. In principle, it is prohibited in Flanders to throw (biodegradable) plastic or food packaging into the biodegradable waste container. Biodegradable waste that is collected is also pre-treated and sieved to remove impurities. Greater impact is therefore expected in gardens where home-produced compost is used.

5.7.3 Landfills

Landfills can also be a source of all parameter groups. A distinction can be made here between the more recent regulated landfills and historical landfills.

In 2018, there are still 10 licensed landfills in Flanders that accept waste from third parties.
In addition, there are also 'mono-landfills'. These are landfills for one specific type of waste that is released in large quantities. Spread over Flanders, however, there are more than 3,000 historical landfills (OVAM). These locations can as such be regarded as diffuse soil contamination. In addition, they can spread contamination further via transport via wind and leaching.

5.7.4 Waste incineration plants

Waste incineration plants can give rise to emissions of various parameters, mainly via the flue gases on the one hand and the ashes on the other.

1. **Area around waste incinerators**
   The flue gases can cause atmospheric deposition in the vicinity of the waste incineration plants. Newer installations are equipped with flue gas scrubbers, which reduce contaminant emissions.

2. **Landfills**
   When waste is incinerated in waste incineration plants (WIP), on the one hand fly ash is produced that is carried along with the flue gases, on the other hand bottom ash is created which remains in the furnace.

   Fly ash from household waste incineration plants (WIP) is referred to as WIP fly ash. WIP fly ash is not suitable as a secondary granulate and is dumped in landfills.

   Bottom ash traditionally exhibits problems with leaching of heavy metals, mainly copper and zinc, whereby mainly the leaching of copper and zinc must be considered. The fraction of WIP bottom ash that has to do with this problem is the finer (sand) fraction, of which approximately 110 kton is released annually. This sand fraction (< 6 mm) is therefore used as an intermediate cover at landfills.

3. **Reuse of bottom ash**
   Before using bottom ash as a building material, it is mandatory to check whether it does not involve environmental risks (VLAREMA). In addition, a raw material declaration is mandatory.

   Bottom ash from household waste incineration plants, however, is not suitable as an alternative raw material without processing and must always be treated. Due to the leaching of heavy metals, bottom ash is often used in bonded applications (shaped building material or in unshaped building material) and usually not as unshaped building material. The raw material declaration also checks whether the material in which bottom ashes are used meets the leaching criteria.

   In Flanders, 260 kton of bottom ash is produced annually, the majority of which comes from household waste incineration. However, most (> 80%) of the processed bottom ash is disposed of in Wallonia. In total, 44 and 56 kton bottom ash were used as building material in Flanders in 2011 and 2012. And yet, for environmental hygiene reasons, considerable quantities of bottom ash are also dumped. In 2011, 19 kton was dumped in category 1 landfills (hazardous waste) and 129 kton in category 2 landfills (non-hazardous waste). In 2012 this increased to 22 and 164 kton, respectively.

The reuse of the ashes is currently regulated and monitored. No new impact due to this source is expected.

5.7.5 illegal dumping and litter

Illegal dumping can also give rise to diffuse contamination. The parameters involved depend very much on what exactly is dumped.

It is not easy to find the location of illegal dumping. It is often cleaned up by the owner of the land on which it is left. Information, if it is available at all, is therefore spread over municipalities, road managers, waterway managers, nature managers, etc.

In this context, illegal dumping of drugs waste is a known problem. Locating the suspected area is not easy. However, the potential consequences of dumping drugs waste are rather large.

Soil studies in response to calamities involving drugs waste are registered by the OVAM (tag). The locations of these studies could be examined to see if this is more common in certain regions.

5.7.6 Waste (water) summary

Table 5.7: Summary of the impact of waste (water) on diffuse soil contamination

Suspected area	Localiztion Suspected area	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps/uncertainties/refinements	Possibilities for supporting evidence of the impact
Sewers	Known (geopunt), possible to refine based on age of sewage system (known in geopunt, even though many strands show the start date 1970 (default value if unknown?))	Residential area, groundwater	All parameters (1)	Leaking sewers	moderate	+ - Fairly dense sewer network in Flanders - Much of it already quite old (1970s?). + - Underground source	No measurement data available.	• sewers in areas with, for example, heavy industry or in a large city are more suspected than a rural village, given the expected higher contamination load. • based on the VMM database, at least for the more recent years, it can be determined which companies discharge which contaminant load into the sewer system. • Based on figures for the population density in Flanders, potentially more suspect zones can be delineated for the parameters rather emitted by households into the sewer system (e.g. PCPP)
Sediments and banks	Location of waterways is known, to be refined based on the location of sewage treatment plants, sewer overflows, discharges from industry, certain activities (e.g. festivals)	Aquatic ecosystems, drinking water extraction from surface water	All parameters (1)	Industrial and household discharges, run off,	large	- Large area impacted, - very many different parameters, including persistent substances	• Little info about vaulting and enclosures • Little information about where cleared sludge has been placed on the bank and the quality of this sludge. Info is usually not digitized and is spread over the various waterway managers • New scheme for reuse of soil materials: no solution for parameters that are not in SAP sediment.	• Traceability of dredged sludge that is permanently deposited on the banks has already been included in the new regulation for the reuse of soil materials. Disclosure of the data can provide a lot of useful information. • Drainage overflows can be expected to be more heavily diffused in environments with a lot of industry or near waste water treatment plants. • Further inventory of existing measurement data (see Sediment explorer) • Suspected zones due to industrial activities may be determined based on the data from the IMJV and the measurement data (waste water, sediment and surface water) from the VMM, or using the municipal inventory and/or NACE codes • Dredgis database analysis data
flood areas	Location known (geopunt, etc.)	Dense waterway network, spread across Flanders - through sensitive land use (residential area, agricultural area, etc.)	All parameters (1)	floods	Large	- Large area impacted, - (theoretically) many different parameters, including persistent substances	No analysis of available measurement data yet	• The INBO and the Vlaamse Waterweg have measurement data of the soil in controlled flood areas • Analyse data from existing monitoring networks
agricultural area	Location known in the Flanders spatial model, agricultural plot use database, etc.	Food and feed crops	All parameters (1)	Fertilization with sludge from water treatment, irrigation with purified waste water, surface water	Large	- sensitive receptor, - persistent parameters involved, - large area, - possibly significant historical load.	Little measurement data for soil, but there is for groundwater.	• Analysis data from the phreatic groundwater monitoring network (mainly placed in agricultural areas) • Presumably data available from the Vlaco. Inquire if it can be shared.

Suspected area	Localiztion Suspected area	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps/uncertainties/refinements	Possibilities for supporting evidence of the impact
			PFAS/plastic	Fertilizing with digestate or compost	limited	+ Especially encountered when coming from household and organic waste that also contains food packaging. Biodegradable waste Is pre-treated in Flanders to remove food packaging. - + PFAS Possibly also via sludge from paper factories (historical)	No Flemish measurement data freely available	
Gardens and public green areas	Residential areas known in the Flanders spatial model.	residential areas	PFAS/plastic	Compost from own compost bin	limited	Impact difficult to estimate. No standards available. + Probably more likely a local problem	Greater risk when using your own compost No direct measurement data Indirect: human biomonitoring: link between PFOS and the consumption of local eggs	/
beaches	Location known	Beaches	Plastic, plasticizers, flame retardants	Plastic washing up	Moderate	+ - Moderate area, easy to locate	Little known about effects	• Studies ongoing at the ILVO and RBINS-OD nature
landfills	Most suspected locations are easy to locate (OVAM inventory, Flanders spatial model)	Spread across Flanders, also in sensitive land use	All parameters (1)	landfills	Moderate	+ - Large number of landfills, - possibly persistent parameters, - landfill remains as a source + more likely local effect around the landfill.	Already inventoried by the OVAM? Refine suspected substances per landfill based on period in which they were dumped (GIR) Refine based on type of landfill? Recently regulated landfills are less suspect	• Policy already developed (inventory, ELFM projects, etc.) • existing monitoring network data can be analysed as the location of landfills is known
Area around waste incinerators	An inventory can be made of the locations of (former) waste incineration plants in Flanders. The area to the north-east is most suspect	Depending on the location, presumably mainly industrial area.	ZM, PAH, PCDD, PCDF, PFAS and nanoparticles	Atmospheric deposition of smoke particles	Moderate	+ Rather local effect, - yet significant area that can be affected. Persistent substances	No direct soil measurement data	• Make an inventory of (former) waste incinerators • Newer installations are equipped with flue gas scrubbers, which reduce contaminant emissions, old ones are more suspect • Analyse existing measurement data (groundwater, sediment, air) to determine whether certain of the suspected parameters occur more frequently and/or in higher concentrations than in the rest of Flanders
Area around illegal dumping and litter	Difficult to locate, certain known problem locations may be known to competent authorities (motorway parking areas, towpaths, nature reserves, etc.)	Depending on the location	All parameters (1)	illegal dumping (incl. possible drugs waste)	limited	- If drugs waste: toxic parameters + Rather very local impact	Locations and composition of illegal dumping are not systematically inventoried.	• Analyse cleanliness barometer data: Glass balls, bus shelters and motorway car parks are hotspots

(1) heavy metals, PAHs, mineral oil, pesticides, PCPP, PCDD/F, PCB, flame retardants, plasticizers, PFAS, asbestos, nano and microparticles, radionuclides

5.8 OTHER

This section contains the sources that do not belong in one of the previous categories. These are the sources related to ammunition (war zones, hunting areas, military areas) and fires.

Fires can lead to emissions of various parameters. Approximately 20,000 fires are reported annually in Belgium. Based on the most recent report containing statistics from the Belgian fire service (2015), the location of fires does not seem to be systematically inventoried. The statistics are based on a survey of the 35 different fire service zones. The report does not mention the registration of the location of a fire. If the location is registered, the way may differ from zone to zone, making it difficult to locate the suspected area.

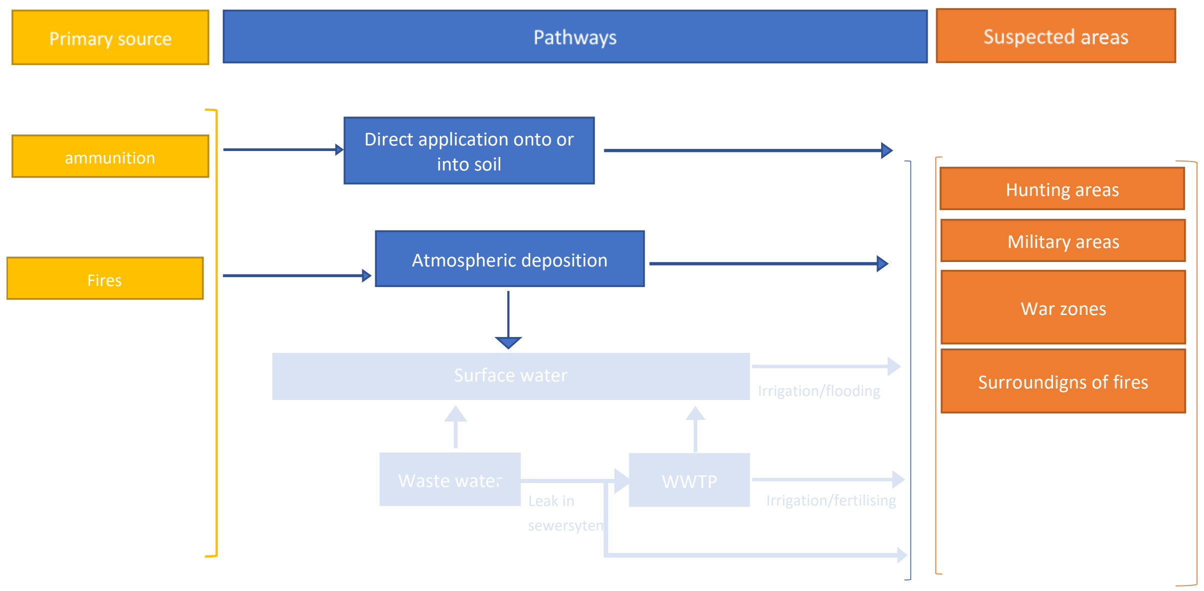


Figure5-10: conceptual site model for other sources

Table 5.8: Other impact summary

Suspected area	Localization of Suspected area	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps or uncertainties	Possibilities for supporting evidence of the impact
war zones	Number of areas identified: around Ypres, “Destroyed regions”, beaches and dunes	All land uses	ZM (copper and lead)	Grenades containing lead and other ammunition	limited	Relatively large area, determined concentrations fluctuate around guide value (for lead, worst case)	/	/
Hunting areas	Hunting plans are known and available at geopunt	Nature and forest area, agricultural area	ZM	Hunting ammunition	Limited	Very local hunting is not very common in Flanders.	No measurement data Exact location difficult to locate	/
military areas	Location of military areas is known.	Military areas	ZM	ammunition	Limited	Local effect, effect in military domains is rather limited considering few receptors	No measurement data	/
fires	Are not systematically inventoried	Spread over Flanders	PCDD/PCDF, PAH, asbestos and PFAS	Flue gases and fire-fighting water	moderat e	Large number of fires, persistent and toxic parameters, little attention for this (more recently for asbestos)	Locations of fires are not inventoried Little or no measurement data (there is for asbestos).	Inquire about fire service areas

6 IMPACT OF DIFFUSE SOIL CONTAMINATION AS A RESULT OF SECONDARY SOURCES: SPREADING OF CONTAMINATED SOIL

Once contaminants are released into the environment or soil, they can migrate further. The pathway taken by the substances is more difficult to trace than for primary sources.

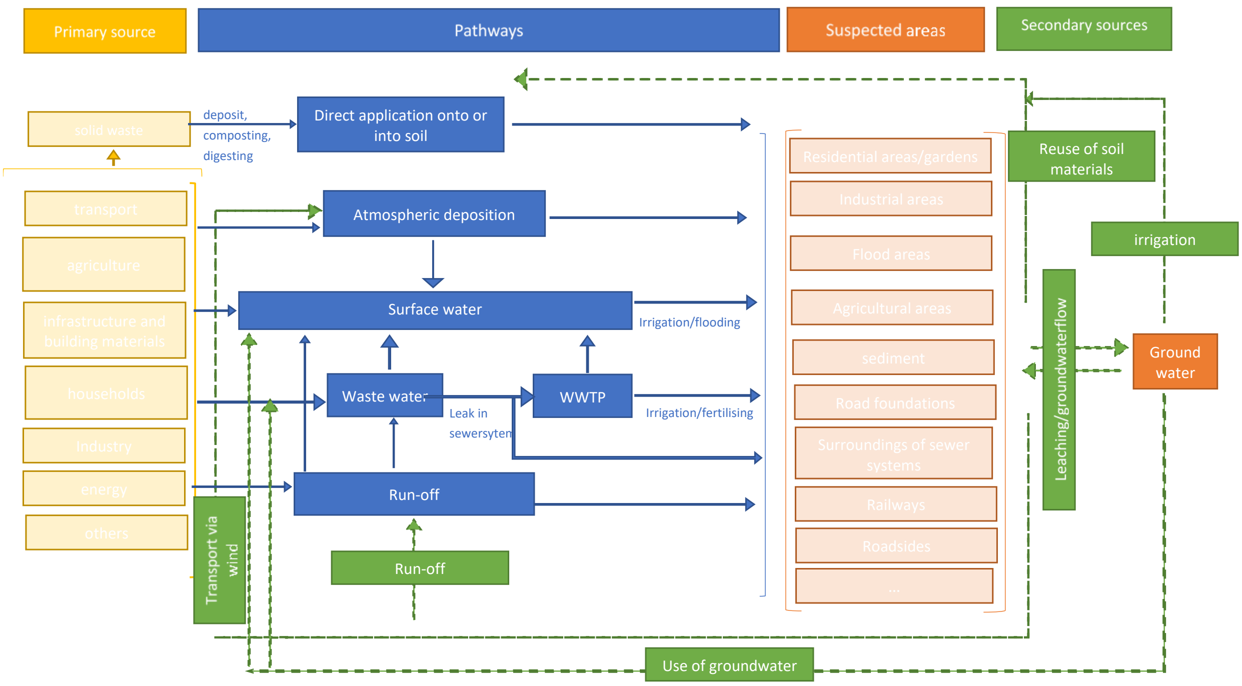


Figure6-1: conceptual site model for secondary sources

6.1 REUSE OF SOIL MATERIALS

When diffusely contaminated soil materials are excavated or dredged and reused elsewhere, the diffuse contamination is also spread.

These ground flows have been traced since the establishment of the soil management organizations. The quality of excavated soil is determined and it is always possible to check which batch of soil has ended up where. However, the number of parameters analysed is limited, parameters such as flame retardants, plasticizers, plastics, pesticides and PFAS are not systematically analysed. Furthermore, there are no data available before the earthmoving regulation came into effect and sludge and sedimentl were only recently included in these regulations. Very small volumes are not covered by these regulations either, although we can assume that many (small) lots are moved in (private) works.

Determining a suspected area is therefore not easy. For this, it must first be mapped from which potentially (diffusely) contaminated locations soil material was excavated and then it must be determined where this soil was deposited. Moreover, with most primary diffuse sources the top layer is mainly affected. During excavation (befor the earthmoving regulation came in to effect), the soil is mixed up, further diluting any contamination.

A few broad lines can be distinguished:

- Cleared dredged material is always suspect. In the past, this material was often used to apply bank reinforcements or was (temporarily) laid on the bank to dewater. Therefore, the banks of waterways can always be considered to be suspect. This has already been included in Section 5.
- A partial inventory has already been made of land that has been raised with dredging material (dredgis database), these areas can be considered to be suspect.
- Elevated areas, where the origin of the elevation material cannot be traced, can also be considered suspect. However, these areas cannot be located.

6.2 TRANSPORT VIA WIND AND RUNOFF

If the top layer of the soil is diffusely contaminated, this diffusely contaminated soil can also spread further via wind and run-off. Here, too, it is not easy to determine a suspected area.

In the case of transport via wind, the areas to the north-east of the suspected zone should mainly be considered, since the predominating wind direction in Flanders is south-west.

For runoff, the nearby waterways and canals should be looked at.

6.3 LEACHING

If the soil is (diffusely) contaminated, the contamination can also leach into the groundwater. It is possible to focus on parameters that leach easily and initially on the phreatic groundwater.

The (diffusely) contaminated groundwater can then spread, via the natural flow direction, or artificially, when it is pumped up for

- irrigation: Contaminants present can spread to agricultural land and vegetable gardens
- Business processes: after use in business processes, the pumped up groundwater can end up in the waste water
- drainage: the pumped up groundwater may end up in the sewer system or in surface water.

6.4 SUMMARY OF SECONDARY SOURCES

Table 6.1: Summary of the secondary impact on diffuse soil contamination

Suspected area	Suspected area location	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps or uncertainties	Possibilities for supporting evidence of the impact
Elevations	Spread over Flanders. Dredging land partly inventoried in the Dredgis database	Potentially different land uses (residential area, agricultural area, etc.)	Depending on place of origin	Moved (diffuse) contaminated soil	large	- Probably concerns many locations. - Had little attention paid to it in the past. - Experience in earthmoving: excavation of soils/embankments often contaminated	Very difficult to locate	• Analysis of future earthmoving data; can this be selected on excavation/soil containing debris?
Banks	Location of waterwaywaterways known, little information available about where cleared sediment was placed	sediment, drinking water extraction from surface water	All parameters (1)	cleared sediments	Moderate	+ cleared sediment was probably not placed everywhere on the banks, so this reduces the impacted area.	Little information about where cleared sludge has been placed on the bank and the quality of this sludge. Info is usually not digitized and is spread over the various waterway managers New scheme for reuse of soil materials: no solution for parameters that are not in SAP sediment.	• Traceability of dredged sludge that is permanently deposited on the banks has already been included in the new regulation for the reuse of soil materials. Disclosure of the data can provide a lot of useful information. • sediments can be expected to be more heavily diffused in environments with a lot of industry or near waste water treatment plants. • Further inventory of existing measurement data (see Sediment explorer) • Suspected zones due to industrial activities may be determined based on the data from the IMJV and the measurement data (waste water, sediment and surface water) from the VMM, or using the municipal inventory and/or NACE codes • Dredgis database analysis data
Waterways	The location of the waterways is known	sediment, drinking water extraction from surface water	All parameters	Run off	Moderate	The contribution of run off to the impact of diffuse contamination on waterways is estimated as moderate	New scheme for reuse of soil materials: no solution for parameters that are not in SAP sediment.	• See banks
To the north east of areas where the top layer is (diffusely) contaminated	Depending on the location, other suspected areas	Depending on the location, other suspected areas	Parameters that easily adhere to soil particles	transport via wind	limited	Potentially large area Diffuse contamination can partially spread further via wind - concentrations/amount will be much lower	difficult to locate/substantiate	• Mapping of suspected areas, also consider area downwind to be suspected
At all suspected areas for soil	Flanders	Phreatic groundwater	Leachable parameters	leaching	Large	Groundwater is seen as a sensitive receptor	difficult to locate/substantiate	• Analyse data from existing groundwater monitoring networks • Map suspected areas, also consider groundwater in these areas to be suspect

Suspected area	Suspected area location	Receptors	Parameters	Most important sources	Impact	Substantiation	Possible gaps or uncertainties	Possibilities for supporting evidence of the impact
Vegetable gardens and agricultural land irrigated with (diffusely) contaminated groundwater	Difficult	Food and feed crops	Leachable parameters	Irrigation with (diffusely) contaminated (phreatic) groundwater	Limited	Number of vegetable gardens irrigated with groundwater is probably limited. Agricultural area impact due to irrigation with phreatic groundwater is probably relatively small compared to impact from other sources (e.g. irrigation with surface water, pesticides, fertilization)	difficult to locate/substantiate	• /

(1) heavy metals, PAHs, mineral oil, pesticides, PCPP, PCDD/F, PCB, flame retardants, plasticizers, PFAS, asbestos, nano and microparticles, radionuclides

PART 3 – POLICIES ON DIFFUSE CONTAMIANTION IN OTHER EUROPEAN COUNTRIES

As part of this study, we also looked at how the problem of diffuse soil pollution is being tackled in different countries and regions of Europe.

Although soil contamination legislation is well established in most European countries, it is becoming increasingly clear that legal instruments are often not suitable to tackle diffuse soil contamination.

In 2018, questionnaires on diffuse soil contamination were sent to the members of the Common Forum on Contaminated Soil in Europe (https://www.commonforum.eu/), initiated by FOEN (Switzerland) and SPW (Walloon, Belgium). The information was collected in two phases: a questionnaire on national and regional concepts and practical approaches to diffuse soil contamination, and a second on specific case studies.

The relevant information about diffuse soil pollution received through the CF questionnaires and reports were summarized for the 15 countries/regions that responded to the questionnaire of the common forum.

In 2020 some additional follow-up interviews were conducted to collect more in-depth information on the existing policy and legislation on diffuse pollution, more specific: (legal) triggers to start investigation and remediation, obligations, responsibilities, liable parties, practical implementation of legislation and cases.

15 countries/regions were contacted, 14 participated in the interviews.

In addition, recent interesting reports and questionnaires are available summarizing how particular issues of soil protection are legally framed and implemented by European countries (and regions):

- JRC 'Status of local soil contamination' (2018)
- Questionnaire emerging contaminants (2016) (https://www.emergingcontaminants.eu/application/files/4014/5648/7939/RW2034-1-16-003.303-rapd03-final_report_Invenory_EC_and_PFAS_in_EU.pdf)

Those reports give general background information about soil policy in Europe.

All available information about diffuse soil pollution" based on the JRC –report, questionnaires and interviews are summarized in the report "Policies on diffuse soil contamination in Europe" (OVAM, 2020). We summarized the main conclusions:

When talking about diffuse soil pollution, participant use different definitions and interpretations. A common definition, would be helpful when discussing this topic in an international context.

A few countries/regions have a specific policy and legislation for diffuse soil pollution, a few exclude diffuse soil pollution from contaminated site programs, but most countries/regions do not differentiate between point source and diffuse pollution. Policy tools however, are mostly designed to deal with point source pollution.

None of the consulted countries and regions have a systematic approach to identify, investigate and register diffuse soil contamination. Diffuse soil contamination will only be discovered "unintentionally" during other investigations or during excavation works. Some countries/regions have soil monitoring programs, which can contain useful data regarding diffuse soil pollution.

When asked which compounds are of highest concern when considering diffuse soil contamination, opinions between counties and regions vary, but heavy metals seem to be a general concern.

When diffuse contamination is discovered, the most common approach mentioned by the participants to deal with this, is soil management, to effectively control the risks that diffuse contamination could (potentially) pose. Mostly because diffuse contamination is usually present over a large area, and it is not cost-efficient or realistic to actively remediate the entire area. Almost every country/region has the possibility to apply restrictions or advice for the use of the diffuse contaminated land.

Responsibilities and liability is often very difficult to determine in case of diffuse soil contamination. In case of construction projects, where excavations are planned, cost are usually covered by the party initiating the excavation (developer). In other cases, participants rely on the policies established for point source contaminations: several countries have set up systems where owners/operators can be cleared of obligations to investigate or remediate a soil contamination when they did not cause the contamination. In these cases, usually the public authorities will, in the end, carry the cost for investigation and if needed for the remediation. In a few regions/countries the owner always carries the responsibility for soil pollution on his site, even when he is not the polluter. In practice this proofs the be hard to implement.

PART 4 – RECOMMENDATIONS

7 POLICY RECOMMENDATIONS

7.1 WHY IS THERE A NEED FOR A POLICY ON DIFFUSE SOIL CONTAMINATION?

A policy on tackling diffuse soil contamination is recommended for several reasons:

- The spread of diffuse soil contamination is often cited as one of the causes of loss of soil biodiversity and loss of soil ecosystem services. There is a need for long-term protection of the soil and its functions.

- Health risks can arise in both the short and long term, e.g. when the soil is used for growing vegetables or keeping chickens. Diffuse soil contamination can affect the quality of agricultural land in such a way that a safe food supply will be made more difficult in the future. Drinking water supplies can also be affected in the long term by diffuse soil contamination. Biomonitoring studies show that there is a lot of influence of contaminants in the human body, it is not always possible to unambiguously identify a cause/source, but soil pollution can certainly contribute to the human burden of contaminants.

- There is often a lack of clarity about the authority to act and the instruments of the Soil Remediation Decree turn out to be insufficient: for example,

    - in soil surveys carried out under the Soil Remediation Decree, norms are exceeded regularly for parameters for which this was not expected, and for which it is often not clear who is obliged to investigate and remediate it. The survey is also limited to the plots on which the activities are carried out. The wider environment, which may be influenced by atmospheric deposition, for example, is not surveyed as standard.
    - Increased concentrations of natural origin are not regarded as contamination according to the soil decree. However, in the context of earthmoving and exposure, it is important to gain insight into the presence of naturally increased concentrations.
    - Within the context of the soil decree, mainly risk land is surveyed, see the Vlarebo. The literature review and study of existing databases clearly show that diffuse soil contamination can also have a major impact due to activities that are not subject to the Vlarebo. However, the soil decree does not require a survey for this.
    - The Soil Decree/Vlarebo is limited to standard parameters. However, literature shows that attention must also be given to a more extensive group of parameters, including emerging contaminants. In addition to a policy on diffuse soil contamination, a policy on ‘emerging contaminants’ (new emerging substances) is therefore also necessary.

- In the context of earthmoving, batches > 250 m³ must always be examined. Here too, the SAP package is mainly included by default. Diffuse soil contamination often involves more than the standard parameters. From that perspective, this document provides insight into ‘suspect’ parameters and ‘emerging contaminants’ (new emerging substances) in the context of diffuse soil contamination.

7.2 APPROACH RECOMMENDATIONS

The soil policy approach to diffuse contamination covers several areas:

- Gaining insight into sources and contamination parameters that can lead to diffuse soil contamination based on measurement data. This can be done by:
  - better data access, as there are many direct (soil) and indirect (emission data, etc.) data available but not yet sufficiently accessible and/or grouped
  - Using and expanding existing monitoring networks (groundwater, surface water and sediment)
  - Control and inventory of reuse of soil materials/sludge/compost/construction waste/manure (based on this study, it becomes clear when it is best to investigate which additional parameters)
  - Laying out a soil monitoring network (ground)
- Filling in gaps in instruments of the soil decree. This includes the need to amend the Soil Decree and the Vlarebo, as well as other instruments such as standard procedures, codes of good practice, technical guidelines, etc.
- Raising awareness and informing citizens (see vegetable garden research, pesticide use, etc.)

The possible recommendations are explained in more detail below.

7.2.1 Sources of diffuse pollution and pollution parameters

On the basis of (international) measurement data, literature research and emissions data, it can be demonstrated that on the one hand a significant impact of diffuse soil contamination from certain sources and on the other for specific substances cannot be ruled out. This degree of impact of certain sectors/parameters was qualitatively determined on the basis of the **emissions** of the parameter group concerned by the source concerned, based on the available direct and indirect **measurement data**, based on the expected **surface area** of the impact (spread across Flanders, rather locally or regional), based on (toxicological) **effects** of the parameter (group) concerned for humans and the environment (persistent, low toxicological (threshold) value, etc.) and based on reaching sensitive receptors (possible **exposure**).

The various sources were grouped into categories. The following categories may have a large diffuse impact on the soil according to this method:

1. Transport: mainly in the vicinity of railways, roadsides and navigable waterways
2. Agriculture and livestock are likely to have a major impact on agricultural land because of the use of agrochemicals and manure.
3. Construction materials and infrastructure: asbestos in the asbestos region, reuse of demolition and construction waste in general
4. Households and services: gardens and public green space (pesticides), heating of buildings/open fire
5. Industry is likely to have a major impact on the surrounding industrial sites in general, specifically the Campine region too: historical metal activities, the area around textile industry, petrochemical industry and asbestos processing industry can be mentioned

6. Waste (water) (including compost and digestate): sediments and banks, flooding areas, agricultural areas
7. Reuse of soil materials: embankments, earth moving
8. Leaching: at all of the above areas

Based on the analysis made, the following parameters may have a major contribution to diffuse soil contamination

- Standard parameters: heavy metals, PAH and mineral oil
- Asbestos
- PFAS
- brominated flame retardants such as brominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD) as well as other organophosphorus ester (PFRs) flame retardants
- pesticides and decomposition products
- Nano and microplastics
- PPCP (Personal Care Products): Triclosan and any decomposition products, antibiotics, substances with hormonal effect (e.g. plasticizers)

An overview of the impact between sources and parameters is presented in more detail in the tables in this study (see tables - part 2 impact)

In general, the main sources of diffuse soil contamination of most substances are the result of atmospheric deposition (transport and industry) and direct application (agriculture, green zones). As a result of soil erosion, waste water discharge and atmospheric deposition, a large part also ends up in water courses (sediment and surface water). Dredging (whether or not in combination with depositing on the banks) and flooding have resulted in secondarily contaminated soils. Earthmoving can also give rise to diffuse soil contamination, as well as the use of rubble for foundations and the like.

A sector-oriented approach (transport, agriculture, households, etc.) may be appropriate, as specific parameters, suspect areas, environmental compartments and stakeholders are also involved in each sector/source. The actions or step-by-step approach will therefore be different and sector-oriented: the actions for the agricultural sector will be different than those for households.

It is therefore necessary to develop actions for a specific sector,

- on the one hand we look at which sources are present in this sector
- and on the other hand at which suspect areas are present within this sector, from possible sources outside the sector (raising awareness)

For example, within the household sector, the use of pesticides and carbon ashes in the garden will be a source within the sector, with the direct effect being limited to within this sector. However, heavy traffic (transport sector) can also have an impact on the quality of garden soil and vice versa, the use of personal care products and the emissions of microplastics by households can have an impact on other sectors such as agriculture and watercourses via the waste water.

A sector approach is not only useful for prevention, but also for further mapping and management of diffuse soil contamination.

7.2.2 Challenges and opportunities in the field of data and measurement data

7.2.2.1 data access

There is a great deal of direct (soil, groundwater and sediment data) and indirect data available (with regard to emissions, etc.) that, provided there is good accessibility, could be an important tool for clearly mapping areas with a high impact of diffuse soil contamination.

- Refinement of the theoretical impact analysis by means of the Flanders space model.
  The Flanders space model contains a number of relevant GIS layers that can be used to estimate the qualitative impact/chance of the presence of diffuse soil contamination. Based on the knowledge related to bringing together sources and impact on soil in this report, it must be examined how this can be combined with existing GIS layers. In this way maps are created that indicate in which areas/zones/etc. diffuse contamination is expected for certain parameters. This can already be a useful tool in the context of earthmoving and determining 'suspect' parameters. If extra criteria can be added with regard to the seriousness or the associated risks (e.g. destination type, risks for agriculture, for drinking water quality), then a first rough prioritization can be applied (see the sediment explorer).

- Access to the data from technical reports can provide an important insight into diffuse soil contamination in the context of the management of contaminated soils (earthmoving). When data from technical reports can be represented spatially, then a (partial) validation of the theoretical impact analysis performed can be estimated based on this data. In order to gain insight into the possible impact, criteria must be drawn up (e.g. exceeding standards for free use, risk of leaching and spreading via groundwater, etc.).

- Access to the data from technical reports can also be a tool for biomonitoring studies. Biomonitoring studies show that many contaminants end up in the human body, but it is not always possible to unambiguously identify a cause/source. Soil contamination can to some extent also contribute to the human burden of contaminants through the ingestion and inhalation of dust particles, through the cultivation of vegetables in the garden and/or through the keeping of chickens. A combination of the biomonitoring data with spatially distributed data from technical reports (both non-Vlarebo and Vlarebo soils) can form an important link here for further targeted policy on diffuse soil contamination and for additional interpretations and correlations with the biomonitoring studies.

- The sediment explorer under construction can be seen as an example. This tool also combines information about existing measurement results with other data layers and criteria in order to provide more insight into the seriousness of the contamination situation in the sediment and also assigns a prioritization. During the preparation of the sediment explorer it was also established that a lot of data (measurement results, etc.) are held by various authorities. In order to refine the sediment explorer, it is necessary to collect more data, starting with access to the information that is already available from the various watercourse managers.

- For diffuse soil contamination, a similar approach can be chosen by making the accessible data from, for example, technical reports, a soil measurement network, indirect measurement data or already available soil data from one-off studies, together with the maps from point 1, available in existing soil databases such as DOV or Geopoint so that it can be easily shared and the user can add other data layers if desired.

- The aim could be to create a map of Flanders that indicates the risk of diffuse contamination in certain zones with a specific colour/score and also indicates for which parameters diffuse contamination may be present. This map layer can serve as an aid for determining, for example, the analysis package required for drawing up a technical report in the context of reuse of soil materials or an exploratory soil survey.

- Access to data is also important in order to be able to set up targeted soil measurement campaigns for either specific sectors or specific contaminants.

7.2.2.2 Existing monitoring systems and measurement networks

A series of existing measurement networks and monitoring systems have already been implemented in Flanders. It can be examined how these existing systems can be further expanded in the context of diffuse soil contamination:

- The VMM phreatic monitoring network is a relevant monitoring network in the context of diffuse soil contamination
    - The phreatic groundwater monitoring network consists of approx. 2000 wells, with a total of approx. 5000 filters and has been sampled since 2004. These are mainly shallow measuring wells in the first aquifer and mainly in agricultural areas, but also in nature reserves.
    - The monitoring network is used for qualitative state monitoring and operational monitoring, the measuring frequency is twice a year for level measurements and quality measurements.
    - Relevant parameters that are measured are cations, anions, heavy metals (As, Ni, Cd, Cr, Co, Cu, Pb, Zn and Hg), trichloroethylene and tetrachloroethylene. Pesticides are measured once a year by means of an LC-MS screening. Once a year there is an additional separate analysis for 18 specific pesticides.
    - It is recommended to further expand the analysis package in the future (e.g. with PFAS, PPCP etc.).
- The sediment monitoring network consists of approximately 300 points where sediment is analysed. The points are sampled over a period of 6 years. Since 2000, 4 cycles have been completed. The following analyses are performed:
    - Triad quality
    - MO, PAH, ZM, OCP (DDTs, Drins, Hexachlorhexanes, Hexachlorobutadiene, Hexachlorobenzene and Chlordanes), PCB
    - It is recommended to further expand the analysis package in the future (e.g. with PFAS, PPCP etc.).

- The VMM air measurement network for Dioxins, PAH, PCB and heavy metals directly measures atmospheric deposition, an important distribution route for diffuse contamination, at 15 measurement locations.
- Atmospheric deposition is an important distribution route for diffuse soil contamination. However, this is difficult to map. The VMM monitors the air quality. To this end, they carry out deposition measurements, dispose of emission data and dispose of models to estimate air quality as well as deposition to surface water. It is possible that this knowledge can (indirectly) also be applied qualitatively to gain a better insight into the diffuse contamination in the soil.

7.2.2.3 Existing management and control systems

Literature and existing research show that the reuse of soil materials, sludge, compost, construction waste and manure can lead to diffuse contamination and can burden large areas with contamination. In principle, control and management systems have already been developed for these sources.

The following recommendations are proposed:

- Control waste water treatment plant/sludge - this sludge may be used on agricultural land under certain conditions, but not all parameters, such as emerging contaminants, are included in the analysis package. An extension of the analysis package would be a simple measure to avoid new contamination or contamination with emerging contaminants.

- WWTP effluent control and screening for a more extensive analysis package can provide additional insights into which substances end up in the environment and the soil via waste water and which must be tackled as a matter of priority.

- Reuse of soil materials:
    - As mentioned above, access to data from technical reports could contribute to better insights into the relationship between sources and impact, mainly because data is also available here from non-risk land.
    - Soil that is relocated (on verges, etc. and for which there is no TV) or soil used as building material should remain transparent/traceable in view of diffuse contamination.
    - in a technical report only the SAP earthmoving package is included as standard analysis. Diffuse soil contamination often involves more than the standard parameters. The earthmoving package can be expanded relatively easily with suspect parameters of diffuse contamination to limit the spread of emerging contaminants, etc., or to confirm or refute a number of theoretical connections from the impact analysis.

- Use of construction and demolition waste: The quality of recycled construction and demolition waste has already been monitored in recent years. With the introduction of demolition follow-up plans, steps have also been taken to increase the quality of these recycled materials. Here too, consideration can be given to the package of parameters for which standards have been imposed.

- In Flanders, Vlaco has been controlling companies that process organic-biological waste materials into raw materials in or as fertilizers or soil improvers since 1992. This quality control results in an inspection certificate, which provides additional guarantees to the customer, also in other European member states. Compost producers can also voluntarily commit to the Vlaco label, an additional quality label for compost. According to the general regulations for the certification (OVAM), the compost must be analysed for heavy metals, PAH, tetrachlorobenzene, pentachlorobenzene, hexachlorobenzene, MO, sum PCB (7), but not for PFAS, plastics, PPCP, etc. in order to obtain the inspection certificate. An extension of the analysis package for obtaining the certificate can be an important added value to reduce the impact of diffuse soil contamination.

- The Flemish Land Agency also systematically collects analysis results of soil and fertilizers as part of manure management. If additional parameters are analysed here, a valuable database can also be created in the context of diffuse soil contamination.

7.2.2.4 <u>Is validation by means of specific measurement campaigns for diffuse soil contamination useful/possible?</u>

In order to make a quantitative impact estimate of diffuse soil contamination, a validation of soil analyses (soil, groundwater and sediment) is necessary. However, it is often combinations of sources and substances, environmental parameters and history that determine the degree of impact of diffuse soil contamination, which means that a specific validation may be expensive.

By analogy with the sediment and groundwater monitoring network, a soil monitoring network could also be rolled out, whereby spatial soil sampling points would be established, a frequency (e.g. 5 annually), and in which - according to progressive insight with regard to, among other things, emerging contaminants - analysis packages can be put forward. It can be noted here that for certain parameter groups with very many components, such as pesticides, pharmaceuticals, personal care products, etc., it is necessary to determine which substances should be monitored in the soil as a priority or as a guide substance.

The sampling points could be chosen in such a way that account is taken of a spread over Flanders, with the theoretical source/impact analyses from this report and with the map layers created from the link with the GIS layers from the Flanders space model. If the network can be linked to existing monitoring networks, e.g. the groundwater or air monitoring network, the biota monitoring network or human biomonitoring zones, or by expanding the analysis package in existing management systems, the location of and the number of required points in the network can be efficiently selected.

This network would also be suitable for monitoring developments. Many sources (e.g. traffic, use of pesticides, PCPP, microplastics) will not disappear immediately, which means that measures will also have to focus on monitoring and managing the potentially diffusely contaminated soils.

'Targeted' - one-off - measurement campaigns, such as those already successfully implemented for 1,4-dioxane and PFAS, can also be very valuable. For example, a specific measurement campaign can be carried out for each sector/source. Such measurement campaigns are a random sample and rather limited in the number of measurements, but can be extrapolated further across Flanders/per sector. Such targeted measurement campaigns can also be valuable in determining the impact and prioritization of certain sectors/sources and/or certain suspicious substances and/or emerging contaminants.

7.2.3 Filling in gaps in instruments of the soil decree

When looking at diffuse soil contamination, there is often a lack of clarity about the authority to act, and the instruments of the Soil Decree turn out to be inadequate.

- Focus on areas that are not covered by the soil decree: agricultural land, areas for livestock and vegetables/fruit cultivation/fire-fighting training areas, etc. How can these pieces of ground be investigated/measures/usage recommendations be imposed?
    - Within the context of new permits, it can be recommended to always conduct a survey.
    - Limited sampling can also be imposed within the context of building permits.

- Focus on (parts of) sites that are investigated in the context of earthmoving, but are not digitally inventoried, and where there is no link with the Land Information Register. The information from technical reports is not linked to plots. It would be an added value to inventory the data of technical reports via a digital system as well.

- On the soil certificate of both Vlarebo soils and non-Vlarebo soils, usage recommendations regarding the possible presence of diffuse contamination can then be defined for users and owners of land. However, this requires amendments to legislation (see section 7.4) and other instruments (standard procedures, guidelines, etc.).

- By analogy with the housing passport and/or mobility score for houses, information regarding the probability of diffuse soil contamination can also be assigned to a plot - this information can, for example, only be kept informative, not binding. Whether or not this score is included in a soil certificate (binding) or making it available in some other way (informative, non-binding) requires further legal consideration (see section 7.4)

- Many of the suspect areas listed in this study are located on public domain (roadsides, railways, canals and waterways, etc.). No soil certificates are issued for these lands and no information can be found in the LIR, although these lands are sometimes also transferred between different authorities and earthmoving works are often carried out on these lands. If scores or recommendations for use are also assigned here, the location of these parts of the public domain must also be unambiguously recorded in the land information register.

7.2.4 Informing citizens via soil certificate or score and raising awareness through accessible campaigns

- By mapping diffuse soil contamination (qualitative, quantitative, model-based zones) and inclusion in the Soil Information Register (or alternative), an indication can be given via the soil certificate (rather binding) or via 'score' (rather informative) if the plot is located in a zone with high/moderate/limited impact for diffuse soil contamination. The possibility of including information on diffuse soil contamination as a kind of “advice on use” for users and owners of land can possibly lead to a legal obligation (see section 7.4).

- For example, a kind of scoring method could be used in which a qualitative score is given (by analogy with Mobiscore on the housing pass), mainly as part of informing the buyer/seller and within the context of the management of contaminated land.

  The idea/proposal could be to start from all data available in the Flanders space model and to translate the qualitative impact into a score to better estimate the probability of a large/moderate/limited impact for diffuse soil contamination.
    - Location of the site: in the vicinity of industry, in an agricultural area, etc.
    - Impact of certain sources in a specific region: in the vicinity of incineration, airport, busy streets, etc.
    - Clear evidence of diffuse soil contamination?
        - Are you located x meters from a busy route?
        - Is your location in the Kempen region (heavy metals)?
        - Is the location in, for example, Londerzeel (asbestos)?
    - etc.

- Increasing awareness will be necessary in the context of prevention and management of contaminated soils:
    - Sector approach, such as
        - Fire Brigade Federation - use of PFAS-containing foam and carrying out earthmoving work on fire training areas. Also important for industry, e.g. companies that have a fire training area.
        - Farmers
    - Individuals, for example
        - Current project “Gezond uit eigen grond” (healthy from our own soil)
        - Limiting pesticide use (see “Zonder is gezonder” (healthier without) project)
        - Coal ash
        - Heaters
        - Location on busy roadss (Curieuze Neuze projects) can also be indirectly translated into diffuse soil contamination, soot particles on vegetables, etc.)
        - Expand housing pass with score for diffuse contamination, and the options available to use the land freely.

7.3 LEGAL CHALLENGES

Author of this chapter: Dominique Devos, Liedekerke advocaten

The approach to diffuse soil contamination presents some legal challenges. A memorandum on this was drawn up by Dominique Devos of Liedekerke advocaten.

This study defines "diffuse soil contamination" as:[1]

- soil contamination due to all kinds of, often small-scale, artisanal activities (including the dumping and incineration of waste), often from the (distant) past, and for which the **source and cause data have usually been lost**;
- soil contamination caused by **dispersed sources**, e.g. atmospheric deposition, emissions from traffic, agricultural practices (fertilizers and plant protection products), discharges, floods, etc.;
- soil contamination that covers large areas is often difficult to demarcate and involves serious risks, e.g. heavy metal contamination in the Kempen region, etc.

The study justifies a coordinated approach to these diffuse soil contaminants on the basis of the loss of biodiversity and ecosystem services they result, the health impact, the current uncertainty about who should act in a specific case and the inadequacy of the current instruments of the Soil Decree. This last point in particular is relevant from a legal point of view. The inadequacy of the current set of decrees is substantiated on the basis of:

- the fact that the Soil Decree would not clarify who is obliged to investigate or remediate in case of unexpectedly found diffuse contamination;
- the lack of inventory of diffuse soil contaminants;
- the fact that there is no periodic or other obligation to investigate, aimed at identifying diffuse soil contamination, which after all is often not referred to as a risk activity in the Vlarebo;
- the need to also regulate *emerging contaminants* (which often occur as diffuse soil contamination);
- the fact that the analysis of parameters suitable for detecting diffuse soil contamination are often not used in the context of the earthmoving regulation.

7.3.1 Recommendations

In order to tackle the inventoried diffuse soil contamination in Flanders, the following recommendations with regard to the instruments from the Soil Decree have been formulated, these are regrouped as follows and then discussed in more detail in Section 7.4.2.

Land information register and soil certificate

1. A link with the land information register from:

    1.1. the data collected within the framework of the earthmoving regulation;
    1.2. the VMM phreatic monitoring network and the sediment monitoring network;

[1] These definitions are sufficient to indicate what is being discussed during the decision-making process, but for the sake of completeness we note that they are not sufficiently clear to establish legal consequences. So they will eventually have to be crystallized more clearly.

1.3. the VMM air measurement network;
1.4. the data in the context of the Manure Decree.

2. Supplementing the content of the soil certificate (or creating a new informative or binding certificate), with:
   2.1. advice for use with regard to diffuse soil contamination;
   2.2. information regarding the risk of diffuse soil contamination.

Risk ground and risk establishments

3. The expansion of the sites covered by the Soil Decree to also investigate soils with an increased risk of diffuse soil contamination.

4. Raising awareness of specific target groups in the context of diffuse soil contamination.

Analyses and measurements

5. The extension of the analysis package for:

   5.1. sludge from water treatment plants, which has practical uses in agriculture;
   5.2. the effluents from water treatment plants;
   5.3. the earthmoving regulation;
   5.4. obtaining a certificate for raw materials from organic-biological waste;
   5.5. the analyses in the context of the Manure Decree.

7.3.2 Discussion of the recommendations

The aforementioned recommendations are elaborated in more detail one by one below. However, we first point out some more general points for attention that arise in the legal investigation of these recommendations.

- In particular, the question arises what the purpose of this exercise is:
  - Do we want to inform people about the presence of a diffuse contamination?
  - Do we want to go further and link recommendations and/or certain restrictions to that information?
  - Or do we also want to link further obligations to this diffuse contamination, such as conducting soil surveys and, if necessary, performing soil remediation?
- Are we not afraid that by means of this diffuse contamination the focus will shift more from the environmental aspect to the health aspect? And that the information will mainly raise concerns from the citizens?

- The question arises as to how this new approach will also be framed within the global context, in other words if there are many people who are going to obtain a new soil certificate containing information that differed from the previous soil certificate. In any case, there will be a deterioration in the message because there will be more contamination than was previously the case. Questions about the concrete impact of this diffuse contamination will also be asked, for example I have already carried out remediation and now I will receive a certificate with additional/other contamination. What is the consequence?

- Implementing these novelties with regard to diffuse soil contamination within the existing Soil Decree is not per se impossible. Strictly legal, additional information can be included in the land information register and on the soil certificate. Adding certain standards and concentrations in the Vlarebo is also not difficult from a legal point of view. The designation of so-called diffuse land and the associated obligations is also not rocket science in itself. The concrete consequence is, however, much more complex in practice: just think of the obligation to proceed to soil remediation and the associated exemptions from the remediation obligation.

7.3.2.1 Data link with the land information register

Current situation
Article 5, para 1 of the Soil Decree specifies in general terms that the land information register contains data that is provided to OVAM in the context of the Soil Decree (and implementation decisions) and the Complex Projects Decree (and implementation decisions).

Whenever information about land is provided to OVAM in the context of these decrees, it is included in the register.

This provision is further elaborated in the Vlarebo, where it is stipulated that a piece of land is only included in the register when certain information is available. This can be information from the municipal inventory or relevant data with regard to the soil quality of the soil (the latter must be determined by specific persons).

This provision is both narrow and broad at the same time. Narrow because certain conditions are linked to the inclusion of information in the land information register, but also broad because the nature and quality of the information to be supplied is not specified.

On the basis of the current wording, information on diffuse soil contamination can be included in the land information register. If, for example, it appears from a soil survey or a police report that diffuse soil contamination is occurring on a particular plot, this information can be included in the register.

As the competent authority, OVAM does, however, have a certain responsibility and also liability to determine whether or not it includes this information in the register. The fact that it is specified in the decree that OVAM is not responsible for the correctness of the information provided to it by third parties does not detract from this.

It is clear that diffuse soil contamination is already included in the instruments of the Soil Decree today if this contamination exceeds the guideline values. Diffuse contamination that originated at one point (such as atmospheric deposition around a particular business park) is largely already contained in the Soil Decree; this because of the notions of "land where the contamination originated" and "contaminated land".

Possible changes

By changing this provision, other information can be included in the land information register. Different policy options can be chosen, such as:

- an **exhaustive** or **non-exhaustive** list of the data that ends up in the land information register;
- the **type of information** that can be included: is it binary information (diffuse soil contamination or not) per parameter, or can a probability of a particular contamination be included?
- granting a **mandatory power** for OVAM to always include this additional data in the land information register, or granting a **discretionary power**, whereby OVAM (on the basis of certain criteria, such as reliability, or relevance for environmental hygiene and human health) health) has the authority to decide whether specific data for a specific land is included in the land information register.

However, with a view to clarity for the citizen and legal certainty (in particular the fact that the existing situation has existed for a 'very long' and is well established), it is strongly recommended to just *supplement* the current regulation if necessary, but not to *change* it. This is to avoid too much confusion arising about which information can and cannot be included in the land information register and by extension on the soil certificate. If this system were to be completely turned upside down, this could result in a great deal of legal uncertainty.

Of course, further specifying the text with a view to including specific provisions in the context of diffuse soil contamination also entails a risk in itself. In any case, legislation cannot encompass all possible cases envisaged. The more specific the legal provision is, the greater the risk that certain cases will be inadvertently excluded (because they cannot be classified under the specific provision).

But even without amendment of the Soil Decree, information about diffuse soil contamination can be included by OVAM in the soil information register. In doing so, OVAM itself can assess which data is "relevant" (and therefore included) and which is not.[2] However, this only concerns information that comes from a number of exhaustively listed sources.[3] For example, information originating from research institutions (e.g. VITO) could not be included, nor could complaints be submitted by citizens/companies directly to OVAM.

On the other hand, the risks entailed by a broad discretionary power for the government should be noted. With regard to citizens, this can lead to uncertainty and data may not always be consistently assessed by different officials. By a (simplified) hypothesis, this could lead to plot A and C being included, but not plot B in between because the information for that plot was judged to be insufficiently relevant. With regard to the government, this also leads to problems: the more discretion the government has, the more government action will be assessed against (generally formulated) principles of good administration, which, because of their casuistic application, entail a risk of government liability for civil courts.[4]

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[2] Article 13, 3°, b) Vlarebo.
[3] Namely from soil remediation experts, police services or government agencies with environmental or water-related powers.
[4] The principle that the government is liable for the damage resulting from the incorrect information it provides is generally accepted in case law. See in general: Ghent 1 December 2011, RW 2013-2014, ep. 12, 466; Brussels 12 April 2011, TROS Newsletter 2012, ep. 11, 7 (summary F. DE PRETER); Ghent 20 December 2002, RABG 2003, ep. 15, 868, note S. LUST.

After all, if a judge were to come to the conclusion that certain information was indeed "relevant" and should therefore have been included, there is a disregard of a specific information obligation that even leads to government liability if the government has not been careless.[5]

It can be deduced from case law that the government has an obligation to correctly inform citizens, at least when they actively request information. The government must also indicate to what extent the information provided is accurate.[6]

Applying these principles to the (often uncertain) information about diffuse soil contamination leads to numerous potential problems. It therefore seems appropriate to provide OVAM with a number of legal tools for the selection of "relevant" data on diffuse soil contamination. What should be considered relevant and what not?

This assessment of the relevance of the information will therefore also have to be done for information relating to diffuse contamination.

If it were OVAM's intention to disseminate information about this diffuse contamination through other channels (e.g. by making it available on the OVAM website or in a separate database created for this purpose, separate from the LIR), it must be ensured that this information is in any case also available in the LIR. After all, it could be argued that OVAM (based on art. 13, 3, Vlarebo) has a mandatory authority (thus, as it were, an obligation) to include information about that diffuse contamination in the LIR if it has it.

7.3.2.2 Providing the information from the LIR to the citizen

Current situation
Article 5.3 of the Soil Decree specifies that the soil certificate identifies the soil and provides an overview of the most up-to-date information available in the land information register about that soil.

Here too, it concerns a mandatory authority: the OVAM is obliged to state on the certificate all information that it has in its possession through the land information register.

Referring to the previous section, we can also point out here that OVAM could currently include information on the soil certificate about diffuse soil contamination.

Possible changes

If the intention is to expand the data supply to the land information register with new data flows, then the question must also be asked whether the intention is that this should also be communicated to citizens.

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[5] Vred. Leuven (2) 13 July 2012, *T.Vred.* 2013, ep. 9-10, (544) 547:
"A typical application case of the due diligence rule is found in the due duty of the executive to provide information to the citizen. *Such information is gradually being regarded as a specific duty of good administration, which can also be invoked before a civil court. In concrete terms, this means that if a specific information obligation is not complied with by the government, no further due diligence assessment is necessary."*
[6] See for example Ghent (9th k.) 19 December 2008, *T.Not.* 2010, ep. 3, (117) 122-123. The court of appeal stated:
"Providing citizens with correct information is an essential duty of good administration, an aspect of the general duty of care. *Liability for providing incorrect information must therefore be approached from the general standard of due care: the government must act carefully when providing information, which means that it must conduct a sufficient investigation or, if necessary, demonstrate that the correctness of the information it provides is uncertain."*

The majority of the soil certificates are issued to citizen at the moment when they are about to acquire ownership of (or another right in rem to) land. It must be assumed that at that moment the citizen will benefit from obtaining as much information as possible about the condition of this land. Not only the buyer (or lessee, etc.) has an interest in this, but also the seller (or lessor, etc.) has an interest in its counterparty being informed as fully as possible about the soil condition.

So when the citizen applies for a soil certificate from OVAM, it does so on the basis of a statutory obligation, but also with the aim of finding out what information OVAM has available about this soil. It is therefore difficult to see what justification one could offer for only selectively making information from the land information register available to citizens who explicitly request it.

Indeed, one might wonder why a government, which has considered certain information relevant enough to centralize it in one database, should not share this information with the citizen who requests it. In any case, this information is already subject to the public nature of government as environmental information and access to this information is guaranteed at decree, constitutional and international law level.

If the argument would be that this information has too large a margin of error to be communicated to the citizen, then one could just as well ask why this information would then be included in a government database. Moreover: uncertain information is also information. One could argue that it is then up to the government to adequately indicate the accuracy of that information.[7]

It therefore seems appropriate to us to make only one selection at the moment when the data is selected that will end up in the land information register. A second selection, in particular about which data from this register is subsequently communicated to the citizen, seems difficult to defend. In this way, the method of inventory will also determine the method of information provision, which is clearer for government and citizens.

However, it seems to us a less suitable option to opt for a kind of 'parallel' data file, the data of which may end up on a 'parallel' (binding or non-binding) certificate (in other words, creating a separate database, separate from the LIR, from which, in turn, a certificate could also be issued, but which would therefore not formally be a soil certificate, but a certificate on diffuse contamination is not recommended). This would create confusion and the average citizen would not be able to distinguish between the two. If possible, one could opt for a publicly consultable website, which is referred to in general terms on the (or perhaps even every?) soil certificate.

Even with such a parallel system, the question arises where the need for such a system comes from. If reliability were to be the distinguishing criterion, then it would seem appropriate to already use that criterion when including that information in the existing database or in a database to be established.

It could be argued that the information available about diffuse soil contamination says more about a region than about a plot itself (for example, in a cluster of three municipalities there is an increased chance of a particular contamination). From this perspective, a graphical representation of

[7] See the above-mentioned case law of the justice of the peace in Leuven: Vred. Leuven (2) 13 July 2012, *T.Vred.* 2013, ep. 9-10, 544.

gradations of (probabilities of) diffuse soil contamination could be geographically displayed on a map that the citizen can consult. However, we must conclude that the citizen who applies for a soil certificate still has an interest in obtaining this information even when it concerns diffuse soil contamination (and even when that information is not 100% certain). We can think, for example, of a farmer who leases a site and, as a link in the food chain, bears responsibility for the safety of the foodstuffs he/she puts on the market. Soil contamination, even diffuse and even potential, can be a decisive element for such a citizen in deciding whether or not to lease a site. But actually the same can be said for citizens who want to create a vegetable garden.

If one opts for a more region-oriented inventory, it would also be more logical to disconnect this information from the land information register - but it would therefore seem logical not to link an automatic survey or remediation obligation to this.

It goes without saying that the way in which the information about the diffuse soil contamination is included in the soil certificate can also determine the way in which this is perceived by the recipient of the soil certificate. It could be opted to include information with regard to diffuse contamination (more) than other information. One could also be more cautious in the wording, e.g. by stating that there is evidence of such contamination, or that there are suspicions, or that it cannot be excluded that such contamination is present on the plot.

Here, it will also be necessary to re-consider whether the provision of information that may be too non-committal provides added value compared to not including any information about that diffuse contamination.
Again, if discretion is granted to the government to provide or not provide certain available information to the citizen (at the request of this citizen or actively posting it online), a government liability risk arises that cannot be fully covered even with clear assessment criteria.

7.3.2.3 Expansion of risk land and risk establishment

Current situation

The risk lands subject to an obligation to survey are defined on the basis of the risk establishments that are or were located there (art. 2.13 Soil Decree).

These risk establishments are listed:
- in Appendix I of the Vlarebo, for establishments that were already operating before 1 June 2015;
- in Appendix I of VLAREM II, for establishments that were only operated from 1 June 2015.

Both lists follow the logic of the establishments classified with an environmental permit or obligation to notify.

This designation of risk land is problematic if one wishes to choose to deal with more diffuse soil contamination in the survey and remediation process in the Soil Decree.[8] Even if the list of risk establishments is adapted to take into account the sources of diffuse soil contamination[9], the

[8] However, it concerns a policy choice that has not yet been made, and is therefore hypothetical.
[9] But that will be difficult for some sources because it is simply not about "facilities" (roads, backfill layers, etc.).

problem still remains that the ‘target group lands’ for diffuse soil contamination will generally be land on which the ‘source-risk establishment’ was never established.

In practice it will probably be impossible to include an automatically applicable rule in the Soil Decree or the Vlarebo on the basis of which land where potentially diffuse soil contamination could be present can be identified. It is difficult to label all land within a radius of thirty kilometres around an airport as risk land because diffuse soil contamination was found on it.

In view of the fact that the concept of risk land has already been definitively established, and in order to make a clear distinction with the ‘real’ risk land, a new category of land could be introduced, which in some cases is subject to a survey obligation.

Also, to avoid the negative connotation with the word risk land, a more neutral term could be used (e.g. diffuse soils) to indicate that category of land on which a soil survey must be carried out because of the possible existence of diffuse soil contamination on the site concerned.

The survey obligation on these pieces of ground due to the diffuse contamination does not affect the need to carry out a soil survey as part of, for example, a transfer.

It can therefore be opted to indicate a new category of land for which OVAM would impose a survey obligation. This survey obligation is not linked to the current or past existence of a risk activity on the plot concerned. On the other hand, we might look for inspiration in the earthmoving regulation (“suspect land”). These include the risk land, but also a few other categories of land for which a technical report must always be drawn up.

It is theoretically possible to grant OVAM the power to designate so-called diffuse soil contamination in the context of diffuse soil contamination (yet to be defined legally enough) - possibly in addition to the land already indicated by law - for which a survey obligation then applies; this by analogy with the obligation to survey land not yet surveyed with potential historical soil contamination.

For example, OVAM could indicate land in the vicinity of an airport in function of approach routes and other data (including the data from soil surveys on nearby land) that must be surveyed in the light of the diffusion contamination. It also seems appropriate that OVAM, on the basis of progressive insight and the results of new soil surveys, can remove the designation as diffuse soil, even before a soil survey has actually been carried out on this soil. A possibility could be built in for the person obliged to conduct a survey to request the cancellation of the designation as risk land.

This immediately brings us to a more fundamental problem: it is possible to designate soils in the context of diffuse soil contamination, but then someone must also:

- conduct and finance the exploratory soil survey;
- carry out and (pre)finance the descriptive soil survey;
- carry out and (pre)finance the soil remediation work[10].

[10] Unless, of course, one would opt to build in a completely own regime for this diffuse soil contamination (whereby, for example, there would be no automaticity to carry out a descriptive soil survey and subsequent soil remediation work if the standards are exceeded)

The problem of the innocent owners immediately starts to arise (for the mandatory survey moment for the exploratory soil survey, and for all descriptive soil surveys and soil remediation). An exemption option applies to these obligations, which will apply in the great majority of cases.

This is a problem that has no legal solution: it requires a policy choice with potentially far-reaching implications. Will the current status of the innocent owner be maintained for the diffuse soil contamination (whereby the financial burden for the remediation of the historical liabilities falls to the government) or will the current status be abandoned (and the financial and operational obligations will be partly or fully borne by the citizen)? One could also think of "interim solutions" with a framework policy, such as a soil remediation fund that is financed by the sectors responsible for the diffuse soil contamination (transport, aviation, agriculture, etc.).

When determining the parameters that should cause more diffuse soil contaminants to 'flow' in the survey and remediation process from the Soil Decree, these parameters can be strategically determined as a function of the contaminants to be tackled as a priority, but also as a function of the sectors that have caused them - provided, however, there is a clear and objective justification for this.

For example, one can choose to design the survey policy in such a way as to further confirm the relationship between certain sources and certain contaminants. Subsequently, a sector-oriented awareness-raising policy can be pursued for these source activities.

However, what does not seem possible to us - but we understand that this is not currently being considered - is to determine one specific parameter and to determine that exceeding that parameter only gives rise to a survey or remediation obligation if the remediation obligation belongs to a specific business sector. Such a sector-oriented policy with regard to the remediation obligation seems to us very difficult to reconcile with the principle of equality and non-discrimination.

Finally, one could also pursue a differentiated policy depending on the type of diffuse contamination that one finds.[11] Today, this distinction already exists largely because some types of diffuse contamination are more easily covered by the current Soil Decree, while other types of contamination are less likely to end up in a survey and remediation process, or will almost automatically be in the hands of an innocent owner.

In any case, if it is subsequently determined which diffusely contaminated soils end up in a survey project, a new question arises: must that survey be as far-reaching as the already known exploratory or descriptive soil survey? If the purpose of such a survey must be to determine whether a certain expected soil contamination is actually present in the ground, can the drilling of a few bores, for example, not suffice?

If the survey and remediation obligation is varied according to whether it is diffuse/non-diffuse, or as a function of the specific type of diffuse contamination, this naturally creates an additional (and therefore more complex) regulatory framework for which the definitions for diffuse soil contamination will have to be reported very clearly to rule out discussion or arbitrariness.

[11] See three parts of the definition from the working document.

7.3.2.4 Raising the awareness of risk groups

Raising the awareness of risk groups for the cause of diffuse soil contamination does not appear to pose any legal problems.

7.3.2.5 Expansion of different analysis packages

Finally, a relatively simple measure is to expand the existing analyses of flows that can lead to diffuse soil contamination.

This can be done by changing the standards (implementation decisions or codes of good practice) in which the analysis methods are prescribed.

However, this can have major, possibly even undesirable consequences.

If a particular substance is included as a contamination parameter, concentrations will normally also be determined.

Exceeding these concentrations will in turn mean that measures must be taken with regard to the approach to this contamination (and this according to the system provided for in the Soil Decree).

In other words: where it could be argued that the inclusion of information about diffuse soil contamination in the land information register (and by extension also on the soil certificate) can to a certain extent be separated from certain obligations arising from the Soil Decree, this is no longer the case if standards are set for certain contamination parameters for diffuse soil contamination.

If a new standard is exceeded, the rules of the current decree will have to be applied. These standards can therefore trigger a survey obligation or a remediation obligation. This could also lead to restrictions within the earthmoving regulation. Whether this is a desirable development from a policy point of view is a completely different matter.

8 DEVELOPMENT OF A POSSIBLE SCENARIO FOR THE POLICY ON DIFFUSE SOIL CONTAMINATION

Taking into account the recommendations and advice from the above paragraphs, a number of possible scenarios were developed for a policy on diffuse soil contamination. These different scenarios were presented in an online workshop to various actors (experts, lawyers, contractors, soil management organisations, etc.) from the soil sector. These scenarios were compared in terms of consequences for the survey and inventory obligation, limitation and remediation obligation, costs, legal impact, impact on the soil certificate, awareness-raising, etc. (Appendix 2).

Based on feedback received in this session, the scenario below was compiled for as a suggestion for a policy on diffuse soil contamination.

<table>
<tr><th>Basic scenario principles</th></tr>
<tr><td>The policy could be developed through various aspects
- Identification of so-called “diffuse soils”: zones can be indicated where there may be an increased risk of the presence of diffuse soil contamination; in these zones, in the event of a soil survey (OBO or technical report), the possible diffuse contamination must be taken into account, at least when making the choice of the suspected substances to be analysed.
- Further clarification within existing standard procedures: an examination can be made of which matters in the standard procedures within the current regulatory framework can be improved in order to better investigate diffuse contamination from known sources (for example atmospheric deposition).
- Thematic strategies: separate strategies can be developed for a number of priority themes. Here, priority is given to “sensitive areas” such as gardens, residential zones, parks and schools where there are no risk activities and agricultural areas. It will be necessary to strive for an approach at a higher level than that of the individual plot (municipal level, line route manager, sector organisations, etc.)

The aim of this approach is always to correctly advise users/owners/potential buyers about the possibilities for use of a land and to provide tools to deal with any diffuse contamination.</td></tr>
<tr><th>Practical details</th></tr>
<tr><td>In order to develop this scenario practically, the diffuse soils will have to be visualized and/or georeferenced: creation of a website or making maps available indicating which areas may be diffusely contaminated and with which substances (= “diffuse soils”). These soils can then, in due course, when the maps have been sufficiently substantiated and tested, be included in the LIR as a new category of land (not as risk land).

For the preparation of these maps, sufficiently reliable and representative data is necessary to link the relationships between diffuse contamination with certain components to possibly impacted areas. The possible data sources and possibilities for further survey were listed in this study. Several steps are still necessary to arrive at usable map layers:</td></tr>
</table>

- Sharing and access to certain data (e.g. data from technical reports, other agencies, information from raw material declarations, etc.)
- Map layers can also be created/supplemented via modelling (analogous to the WEISS model for surface water)
- Conduct exploratory studies to confirm/refute certain connections
- It is also possible to further focus on initiatives whereby citizens or companies voluntarily provide data, such as in the “gezond uit eigen grond” (healthy from your own soil) project.
- Determining priority substances for certain extensive parameter groups such as pharmaceuticals and personal care products or biocides.

The maps could be built up per theme (e.g. roadside theme, agricultural land theme, residential area theme, atmospheric deposition theme, material use theme, etc.) or per parameter group, depending on what data is available and which areas/components are treated as a priority. By analogy with the “sediment explorer”, on the basis of various criteria one could assign codes on the basis of which it becomes clear which municipalities/specific areas/zones should be investigated first or where the areas with ‘highest’ risk of diffuse contamination are located. If necessary, links can also be made with information from human biomonitoring campaigns, VMM information (air and water), etc. The map could then be systematically refined on the basis of measurement data that are already available and knowledge gathered in new studies on the various themes.

Obligation to investigate and inventory obligation

Obligation to investigate via existing instruments (such as standard procedures) or additions thereto (for plots requiring survey)
Mandatory consultation of this tool/map material can be included in the standard procedures for drawing up a technical report and exploratory soil survey. This tool should then be consulted by the accredited soil remediation expert when drawing up a TV and OBO for determining suspect parameters (including emerging contaminants).
Consideration can also be given to implementing a limited technical report (with limited sampling) (adjustment of standard procedures) independent of the amount of soil that will be excavated if the soil is marked as “diffuse soil” (the criterion that at least 250 m^3 of soil must be excavated before a technical report is necessary, is scrapped for potentially diffuse polluted areas).

Survey through new survey strategies
For such soils, a separate additional survey strategy could also be defined in the standard OBO procedure or existing strategies could be imposed compulsorily (e.g. strategy 2 for atmospheric deposition and unpaved debris layers (analogous to asbestos), or survey of a discharge point, etc.).
- It may be interesting to work with mixed samples in connection with a specific strategy for diffuse contaminants;
- It must also be specified in the standard procedure when there is diffuse contamination and how this must be demonstrated in the survey, for example: found in X number of mixed samples of a certain soil layer
- surveys in which diffuse contaminants are found can be given the label “diffuse” so that the data can easily be selected from Mistral and processed in the map layers.

Data collected from these surveys and technical reports can be used to refine the maps further.

In this way, diffuse contamination present on plots subject to survey and during excavations will be dealt with better. However, this strategy does not provide an answer to diffuse contamination on sites that are not subject to survey and where excavation is not carried out for infrastructure/construction works. A specific approach will have to be drawn up for these areas, possibly using the thematic approach, described below.

Additional thematic approach for diffuse soils
A start can be made with prioritizing and tackling a few areas. The workshop with the soil sector revealed that the majority of participants considered the agricultural areas and sensitive land without risk activities such as gardens, parks, schools and residential areas along a line route, etc. to be a priority.

An approach at a higher level than the plot level is preferred here. Various options can be elaborated here, for example:

- For private gardens, for example, an action could be set up in collaboration with local authorities in the context of "gezond uit eigen grond", whereby the municipality takes care of contacts with the lab, calls on residents to participate, distributes material, collects the samples centrally, etc. This could bring several benefits:
    - this could reduce the cost and administrative burden for individual participants and enable more people to participate
    - more people are informed and receive detailed advice on whether their land is suitable for starting a vegetable garden or keeping chickens
    - if the results are shared with the government, this also contributes to a better understanding of diffuse contamination, people can be encouraged to do so via this route.

- it could be mandatory to perform a one-off sampling and analysis of the soil when applying for a building permit or subdivision permit. Depending on the result of this, it can be made mandatory to carry out a further survey (OBO) or certain advice can be given regarding the possible use of the plot (e.g. where no vegetable garden should be placed, which type of pavement to use, etc.). It is important to consider critically what threshold is used for such obligations, so that this does not remain a mere administrative burden but also provides useful information.

- A separate survey program could be set up for schools in areas that are potentially diffusely polluted and guidelines on how to deal with this could be developed. This can possibly be linked to existing programs for schools (e.g. for asbestos)

- A lot of additional survey work is still required for agricultural land. In Flanders, very little data is available on contamination of agricultural land. In theory, agricultural land can also be contaminated with a very wide range of components. It must be ascertained for which substances diffuse contamination can actually be present. Within certain parameter groups such as pesticides, it will also be necessary to check which are the relevant priority substances. It is possible to collaborate with sector organisations to collect this data.

Farmers already have soil samples analysed on a regular basis within the context of the manure decree. Sector organisations may be able to motivate some of their members to allow additional analyses on these samples for the mapping of diffuse soil contamination if they also receive adapted advice on their soil based on the results. The added value for owners and users must be emphasised here.

- For surveys into diffuse contamination along certain line sections (railways, motorways), a collaboration could be set up with the manager of the line section.

It is important to note here that the survey results collected in these frameworks aim to bundle information and provide advice and are not directly linked to a further survey or remediation obligation.

Further survey obligation and/or remediation obligation

If diffuse contamination is found in a OBO mandated by decree, the current procedures are followed:
- Determining if there is a clear indication of a serious threat (CIST) (- whether or not BBO is required
- Implementation of the BBO: the contamination is limited, determination of historicity, risk evaluation
- if necessary, remediation, usage advice, etc.

However, diffuse contamination will often involve limited elevated concentrations, so there will not always be a need to carry out a BBO. Moreover, demarcation and determination of the historicity of diffuse contamination are also difficult to achieve and may not always be meaningful, many sources are and will still be present (traffic, waste water, agriculture, etc.).

As a result, the emphasis of the policy on diffuse soil contamination should be on giving advice for use in order to be able to properly inform owners and users about the condition and possibilities for use of their land.

In the event of diffuse contamination, it can therefore be useful to provide the option of giving advice on use in the preliminary soil study phase already or on the basis of results from survey programs, without further action being linked to this.

In a later phase, when the maps are sufficiently substantiated and developed, consideration can be given to assigning specific usage recommendations solely on the basis of the maps (= drawing up spatial usage advice maps).

If diffuse contamination is found in concentrations that make a descriptive soil study necessary, an adapted survey strategy can be developed within the standard descriptive soil study procedure for diffuse contamination. The aim of this strategy would be to:
- examine whether complete curtailment is possible/useful
- see whether determining the historicity is useful/meaningful

• examine whether there are risks and whether they must be tackled by active remediation or whether management/follow-up is sufficient/better and/or define usage recommendations • Here too it may be interesting to work with mixed samples; • here too, it must also be specified in the standard procedure when there is diffuse contamination and how this must be demonstrated in the survey, for example: found in X number of mixed samples of a certain soil layer • These surveys in which diffuse contaminants are found can be given the label "diffuse" so that the data can easily be selected from Mistral and processed in the maps.
Cost
Initially, there is only a limited additional cost for owners/users of risk land or land on which an excavation will take place: a survey was already necessary for TV or OBO. If there is stricter supervision of the application of certain (new or existing) sampling strategies this can also entail a limited additional cost. By developing additional sampling strategies for diffuse soils, excessive or less meaningful survey and remediation efforts can be avoided. For more excavations, a TV will be needed (since the limit of 250 m³ is omitted for diffuse soils), this can have an influence on the costs for smaller projects such as the building of a house. Including additional suspect substances in the technical report or^preliminary soil study based on the map with potentially diffusely contaminated soils is a limited additional cost (additional analyses). When setting up survey programs via sector organisations, municipalities and schools, the costs will differ per program and can be divided among the various stakeholders. Although some will probably be borne by the authorities: • For example, in involving the municipalities in a healthy vegetable garden campaign, residents can finance the analyses but a budget may be needed to support the municipalities • a budget from the government will be needed to develop advice for schools in diffuse polluted areas • for the agricultural land, public funds will also be required in the initial surveys/additional analyses of samples taken in the context of the manure decree. • for line routes in sensitive areas, a support mechanism for the route managers can be developed. **Longer term** Through the above combined approach (via existing instruments and a new thematic approach), links between certain sources and substances will be confirmed or refuted on the basis of the earthmoving data and data from soil studies with the label diffuse (if digitized and analysed). This enables the maps to be refined even more. In the longer term, these maps can also be used to more easily locate a possible receiving ground for earthmoving, and it could develop into an area-oriented approach. This can also reduce costs for smaller projects. For example, if lightly diffusely contaminated soil may be reused in zones that are also designated as diffusely contaminated with the same parameters.

What does this mean for the soil certificate?
In the long term, once the maps have been finalized and the pieces of ground have been included in the LIR, the soil certificate could then specifically state "diffuse soils". As long as the diffuse contamination has not been confirmed in a soil study, a specific statement will be made on the soil certificate for the diffuse soils, stating that the soil may be diffuse contaminated and with which parameters, with a reference to the map/website. If diffuse contamination has been established, this can be stated as such on the soil certificate, together with any specifications (e.g. current management plan, usage recommendations and restrictions).
Raising awareness
This scenario (combination of refining/adapting procedures and thematic approach) will on the one hand raise awareness among certified soil remediation experts and allow them to think further about suspect substances and, on the other hand, the areas with the greatest potential impact can be dealt with priority and specific target groups (people with vegetable gardens, schools, creches, farmers) can be made aware.

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10 APPENDICES

10.1 APPENDIX 1: MATRIX OF SOURCES OF SUBSTANCES, MATRIX DATA AND DATA LIST

10.2 APPENDIX 2: SOIL SECTOR WORKSHOP DISCUSSION SCENARIOS FOR POLICY ON DIFFUSE SOIL CONTAMINATION

A study commissioned by OVAM is being drawn up on diffuse soil contamination in Flanders. This study makes an inventory of what information about diffuse soil contamination is already available, makes an initial estimate of the possible impact of diffuse soil contamination and will formulate recommendations about whether and how a policy can be developed in this regard.
In the context of this last exercise in which a possible policy is considered, a workshop is being organised with various parties from the soil sector (experts, contractors, lawyers, etc.) to look at the problem of diffuse soil contamination from various angles. This document was prepared in preparation for this workshop. In order to arrive at a concrete discussion, a number of lines of thought are elaborated in the paragraphs below regarding what a policy on diffuse soil contamination could look like and what implications this entails in various areas. This document is intended purely as a basis for discussion. In preparation for the workshop, an internal consultation on legal aspects has already been organised.

1. Step 1: identifying diffuse soils

If a policy on diffusely contaminated soils is developed, it is on the one hand important to be able to determine which soils may be diffusely contaminated and therefore need to be tackled. On the other hand, prevention of the occurrence of diffuse soil contamination is also important, either by focusing on the primary source (emission) or by preventing further spread of contaminated soils/materials.
As a first step, it is therefore necessary to identify which soils may be diffusely contaminated and which consequences can be linked to this. We call these soils the "diffuse soils". As a basis for discussion in the workshop, 3 scenarios are developed in which the pieces of diffuse ground are identified in a different way.

Table 10-1 scenarios for discussion

Scenario 1A	**Scenario 1B**	**Scenario 1C**
Zones are designated with a risk of diffuse contamination → the focus is on informing experts in the field of earthmoving and OBO in order to determine the suspect substances. The current approach for OBO (screening strategy) and TV will be maintained. These "Diffuse soils" are not included in the LIR	Zones are indicated with a risk of diffuse contamination ==> the focus is a targeted inventory of diffuse soils These "diffuse soils" are included in the LIR as a **new category of land**	Zones are identified with a risk of diffuse contamination, the current approach for OBO (screening strategy) and TV will be maintained. As part of the TV and OBO preparation, additional information is made available to experts. These "diffuse soils" are included in the LIR as **risk lands**
Objective	**Objective**	**Objective**
Website/map in which certain soils are coloured/defined as potentially diffuse contaminated, we call this the "diffuse soils". It will be mandatory to consult this tool when preparing a TV and OBO to determine suspect parameters (including emerging contaminants). The approach/survey is combined with current obligations. This scenario mainly leads to a broad inventory in the longer term, since no additional survey obligation is defined.	Website/map in which certain soils are coloured/defined as potentially diffusely contaminated, we call this the **"diffuse soils", we include these soils in the LIR as a new category of land (not the same as a risk soil)** Obligations for the tackling/survey of diffuse land will be expanded. This scenario leads to an active soil policy on diffuse contamination.	Website/map in which certain soils are coloured/defined as potentially diffusely contaminated, we call this the **"diffuse soils", we include these soils in the LIR as risk soils.** The approach to the survey obligation and remediation obligation has already been defined in the current Soil Decree This scenario leads to an active soil policy, but with a strict/active approach in the event of contamination that may be too far-reaching in the context of diffuse soil problems (active remediation, BATNEEC, etc.)
Survey obligation and inventory obligation	**Survey obligation and inventory obligation**	**Survey obligation and inventory obligation**
• The survey obligations are limited to the plot(s) included in the OBO of the existing risk soil(s) or to the excavation zone of the technical report. • If necessary, the criterion of at least 250 m³ of soil for the technical report will be scrapped for potentially diffuse contaminated areas. (marked as diffuse on the website = suspect ground)	A separate survey obligation (separate definition of reasons for the need for a survey) can be linked to those pieces of diffuse ground, for example: - requirement in the case of application for an environmental permit, in case of demolition, fire, etc. - The criterion of at least 250 m³ of soil for a technical report is scrapped for potentially diffuse polluted areas (marked as diffuse on website = suspect soil).	A great many new plots that were previously not subject to survey are now, for example in the context of transfer. Under the current regulation, this OBO must also take place before 31/12/2027.
Demarcation and Remediation obligation	**Demarcation and Remediation obligation**	**Demarcation and Remediation obligation**
If diffuse contamination is found in an OBO, the current procedures are followed: • Determining if there is a clear indication of a serious threat - whether or not BBO is required • Implementation of the BBO: the contamination is marked, determination of historicity, risk evaluation risk assessment • if necessary, remediation, usage advice. However, diffuse contamination will often involve limited elevated concentrations, so that the emphasis will be on giving advice for use.	A new follow-up process is being developed for the further survey and approach to diffuse soils. Demarcation and determination of the historicity of diffuse contamination are also difficult to achieve and may not always be meaningful, many sources are and will still be present (traffic, waste water, agriculture, etc.). If a new process is developed for diffuse soils, this can be taken into account • examine whether complete demarcation is possible/useful • see whether determining the historicity is useful/meaningful • examine whether there are risks and whether they must be tackled by active remediation or whether management/follow-up is sufficient/better and/or define usage recommendations	If contamination is found, the current procedures are followed: • the contamination is marked • determination of the historicity • risk assessment • If necessary, remediation, advice on use, .etc. However, diffuse contamination will often involve limited elevated concentrations, so that the emphasis will be on giving advice for use.

This can lead to discussions about what comes from which source and who is obliged to investigate and remediate (for example, how to determine which part of contamination with PAHs originates from traffic and which part of industrial site? And from which companies at the industrial site?) This can be regarded as mixed contamination or as new contamination for, for example, “emerging contaminants”.	→ who should take the initiative/bear the costs here? The owner? The government? → it will have to be specified very carefully when an increased concentration can be regarded as diffuse and when not. → How do we distinguish between diffusely polluted soils and elevated concentrations of natural origin? This can be regarded as mixed contamination or as new contamination for, for example, “emerging contaminants”.	These points will be less clearly identifiable for diffuse pollution than for classic point sources and can lead to discussions about what comes from which source and who is obliged to investigate and remediate (for example, how to determine which part of contamination with PAHs originates from traffic and which part of industrial site? And from which companies at the industrial site?) Moreover, both sources remain present and add to the contamination load, making it difficult to delimit. Contamination will often be regarded as mixed contamination or as new contamination for, for example, “emerging contaminants”.
Cost of surveys	**Cost**	**Cost**
• Initially, there is only a limited additional cost for owners/users of risk land: a survey was already necessary for a TV or OBO. • A TV will be needed for more excavations (in case the limit of 250 m³ is scrapped). Including additional suspect substances in the technical report or OBO based on the map with potentially diffusely contaminated soils is a limited additional cost (additional analyses).	Diffuse soils will have to be surveyed more specifically (additional triggers for survey).	Extra costs for owners whose land is suddenly identified as risk land. Many will be innocent owners, which means that further survey and remediation costs will be borne by OVAM. → unless the concept of innocent owner does not apply to diffuse contamination and yet a distinction is made between diffuse land and risk land (= scenario 1B).
Legal impact (decree changes, etc.)	**Legal impact (decree changes, etc.)**	**Legal impact (decree changes, etc.)**
• no major changes to legislation necessary, is **only an extra tool that is offered** • the government complies with the obligation to provide information by making the tool and website publicly available.	• The soil decree/Vlarebo must be amended to define the new category of land • The specific survey and remediation process must be included in standard procedures.	• The soil decree/Vlarebo must be amended to be able to designate additional land as risk land. • Legal problems possible, if ground that was not previously designated as risk land suddenly becomes risk land?
What does this mean for the soil certificate?	**What does this mean for the soil certificate?**	**What does this mean for the soil certificate?**
• A **general sentence** is added to each soil certificate that it is always possible to check on a particular website whether the soil is potentially diffusely contaminated. • If the contamination has been effectively established in an OBO/BBO, the soil certificate can be prepared in its current form (no changes)	• The soil certificate specifically mentions “diffuse soils”. As long as the diffuse contamination has not been confirmed in an OBO, a **specific statement** will be made on the soil certificate for the diffuse soils, stating that the soil may be diffuse contaminated and with which parameters, with a reference to the map/website. • If diffuse contamination has been established, this can be stated as such on the soil certificate, together with any specifications (e.g. current management plan, usage recommendations and restrictions)	• For diffuse soils, the certificate will only be issued after an OBO has been carried out (upon transfer, etc.). • If the contamination has been effectively established in an OBO/BBO, the soil certificate can be prepared in its current form (no changes)
What preliminary steps are required to implement this scenario?	**What preliminary steps are required to implement this scenario?**	**What preliminary steps are required to implement this scenario?**

The pieces of diffuse ground must be identified.
→ Making maps/layout decision trees available with zones and/or parameters per sector (located next to the railway? Located next to a fire station? etc.)
 	
Diffuse ground can be indicated on the basis of **different sources**, as the consequences are rather limited:
- To prepare such a map, data sharing with other government agencies will be necessary, a certain validation of this data in the form of exploratory studies will be necessary.
- The map can also be prepared on the basis of:
  • theoretical connections/literature
  • possibly checked with exploratory studies
  • possibly checked by setting up a soil measuring network
  • data from other institutions, e.g. VMM monitoring network
	The pieces of diffuse ground must be identified.
	→ Providing maps with zones and parameters per soil
	
	The designation of diffuse land will have to be well substantiated in view of the possible consequences. This cannot be done solely on the basis of theoretical connections, these will have to be substantiated with survey data. Some in-depth studies will be necessary. A soil measuring network can also be useful.
		The pieces of diffuse ground must be identified.
		→ Providing maps with zones and parameters per soil
		
		In view of the major consequences, the designation of certain ground as risk ground solely because there may be diffuse contamination must be very well substantiated with sufficient data. This will therefore only be possible for certain sources and substances with a clear link.

Raising awareness	**Raising awareness**	**Raising awareness**
This scenario will primarily raise awareness among remediation experts and allow them to think further about suspect substances. A general reference on the soil certificate to the maps with diffuse soils will probably not have much influence on owners/users.	This scenario also raises the awareness of owners and potential buyers and informs them of the specific situation for their soil and any advice for use via the soil survey and soil certificate. In this way, owners become more aware of “soil care”.	This scenario will raise the awareness of owners and potential buyers, but may delay transfers and be disproportionate to the expected impact/severity of the diffuse soil contamination.
Other benefits	**Other benefits**	**Other benefits**

• diffuse contamination (= above GV) will be discovered and tackled
    ○ with a TV: at the time of excavation only at the excavation zone
    ○ With an OBO, if a clear indication of a serious threat is present, the situation will be tackled in its entirety (BBO and remediation if necessary)
 	
• Links between certain sources of substances are confirmed or refuted on the basis of the earthmoving data (if digitized and analysed) → enables maps to be further refined - very long term
• Map can also be used to more easily locate a potential receiving ground for earthmoving
	• diffuse contamination (= above GV) will be discovered and dealt with more quickly (more plots will be surveyed), resulting in a more active policy on diffuse soil contamination
	• By developing a separate process for diffuse soils, excessive or less meaningful survey and remediation efforts can be avoided.
	• Links between certain sources of substances are confirmed or refuted on the basis of the earthmoving data (if digitized and analysed) → enables maps to be further refined - very long term
		• In theory, all diffuse contamination is quickly inventoried and dealt with in this way
		• Links between certain sources of substances are confirmed or refuted on the basis of the earthmoving data (if digitized and analysed) → enables maps to be further refined - very long term

Other drawbacks	**Other drawbacks**	**Other drawbacks**
Any diffuse soil contamination that already poses a risk may not be discovered until late or not discovered (only during (major) excavation works). Consider agricultural land, private gardens, parks, land where an OBO has already been carried out and there are no longer any activities, etc. This scenario therefore has an insufficient preventive effect on soil policy.	• There may be discussions as to whether a certain elevated concentration should be regarded as a classical contamination or as diffuse.	• Given that good substantiation will be required to include ground as risk ground, a number of diffuse contaminations that cannot (yet) be sufficiently substantiated will not be inventoried and tackled. • The classic procedure of demarcation, historicity, determining the person obliged to investigate and remediate will generate many discussions and possibly lead to high costs.
Comments	**Comments**	**Comments**
Quite analogous to some of the Scandinavian countries, only when something happens on the ground (digging, change of use, etc.) does a survey start to determine whether the ground is suitable for the intended use.	• Quite analogous to some of the Scandinavian countries, only when something happens on the ground (digging, change of use, etc.) does a survey start to determine whether the ground is suitable for the intended use. • Pragmatic approach not to conduct pointless surveys and remediation, but still make enough people aware of diffuse contamination and possibilities for use.	/

2. Targeted approach around several themes

Diffuse contamination is a very broad theme involving very different types of sources, soils, receptors and parties. To make the practical implications of the scenarios in step 1 more tangible, a possible approach was worked out more concretely for a number of themes. Consideration was given to which potentially diffusely contaminated soils from the inventory study and/or for which sources a similar approach is possible. A possible approach has been developed for each of these themes.

Table 10-2: scenarios for discussion – thematic approach

next steps - specific approach around several themes			
= scenario 1 (indication of diffuse soils) + Focus on a few themes in order to map the most important diffuse contaminants (see the impact analysis study) more actively.			
1. Investigating diffuse soils where the contamination can still (partly) be linked to a large source: heavy industry, ports, crematoriums, airports, etc. (→ mainly atmospheric deposition)	**2. Survey of line routes and their immediate surroundings with diffuse soils (roadsides, railway verges, banks, flood plains) and adjacent gardens**	**3. Investigation of agricultural land**	**4. Investigation of certain "sensitive" pieces of diffuse ground without activities such as gardens, schools, playgrounds**
Objective	**Objective**	**Objective**	**Objective**
Have the diffuse soils in the wider vicinity of certain sources (industrial sites, airports, ports, etc.) investigated more actively if am OBO takes place on the site of this source. The current survey and remediation process will be maintained.	Mapping the contamination along line trajectories so that zones with possible risks can be tackled. These pieces of ground are screened, after which monitoring and risk management can be applied.	Elaboration of an obligation for sampling agricultural land designated as diffuse land. If contamination is found, further survey is necessary. The possibility of developing a contamination management plan is envisaged.	Investigation of pieces of "sensitive" diffuse ground without activities such as gardens, schools, etc. If necessary, recommendations for use are imposed or a BBO with excavation can be carried out (see asbestos drip zones)
Survey obligation and inventory obligation	**Survey obligation and inventory obligation**	**Survey obligation and inventory obligation**	**Survey obligation and inventory obligation**
During the execution of an OBO on risk land, which can potentially cause diffuse contamination in the wider environment, this "wider" environment must also be surveyed. The OBO/BBO is therefore not limited to the source plot. In this scenario, a change in the OBO survey strategy for risk soils is required, which more strictly requires that diffuse contamination in the wider environment must be surveyed. For this, the sampling strategy will have to be clarified. • mainly focuses on atmospheric deposition • For the majority of the pieces of risk ground, an OBO should already have been carried out. Additional surveys can be required in the following periodic survey. Areas where no activities are carried out in the meantime are not covered.	These soils are currently not risk soils. If this is only surveyed in the case of earthmoving, the inventory will take a very long time and will never be complete: adjacent agricultural areas, gardens etc. will be surveyed very rarely. Given the sources are still present, a survey will always only be a snapshot. A full survey obligation for all these soils therefore makes little sense. It is possible that a limited screening can be imposed on the managers of the line section. Points can then be selected from these to be included in the soil measurement network.	Imposing an obligation on the farmer to have a sample taken periodically. Combine with already mandatory sampling in the context of manure policy? (https://www.vlm.be/nl/SiteCollectionDocuments/Mestbank/Bodemstalen/Verplichte_bodemstalen.pdf) In case of increased concentration, switch to an OBO, with a specific sampling strategy (yet to be developed). The periodic sampling can be regarded as part of a soil measurement network. Open questions: Periodicity? Parameters? Per plot? Per area? Do you also include parameters that may come from other sources? e.g. nearby motorway?	Imposing a mandatory sampling when applying for an environmental permit for all soils in Flanders. If elevated concentrations are found, an OBO must be prepared to determine whether it concerns a diffuse contamination over a large area or not
Demarcation and Remediation obligation	**Demarcation and Remediation obligation**	**Demarcation and Remediation obligation**	**Demarcation and Remediation obligation**
Since this scenario focuses on areas where a link with the source can still be found, the current survey and remediation process can in principle be followed. If plots outside the source plot also need to be surveyed, this will give rise to discussion as to whether and what proportion of the diffuse contamination was caused by whom and who is therefore liable/obliged to investigate (e.g. in an industrial estate with several companies, the relationship between source and contamination is not easy to demonstrate, which makes it difficult). This can be treated as a mixed contamination.	If elevated concentrations are found, delimitation per plot is of little use. If analyses of a number of samples (laid down in the BBO procedure supplement) show that the contamination is present along the route, the conclusion can be extended to all plots along this route. The scale of this should be considered (e.g. extension per municipality? By land use?) Since the line routes (roads, railways) will not disappear and the source cannot therefore be removed, remediation makes little sense. Monitoring and risk management and where	Elaborate specific trajectory, see scenario 1b. Demarcation and determination of historicity of little use in some cases, given that fertilizers are still being used and pesticides are used. Remediation need risk-based. However, diffuse contamination will often involve limited elevated concentrations, so that the emphasis will be on giving advice for use. Possibility to provide a monitoring/management plan (e.g. stop growing certain crops, limit the use of certain substances)	Develop a specific process, focused on user advice If it turns out that it concerns a very local diffuse contamination (e.g. local elevation, coal dust in gardens, etc.), a BBO with excavation can be carried out (see approach to asbestos drip zones).

	possible prevention should be pursued. Certain points can possibly be included in a soil measurement network.		
Cost	**Cost**	**Cost**	**Cost**
Costs for survey and remediation will be higher for the owner/user of the source plot. There are, however, no costs for the owners of the surrounding plots that are included in the survey.	The initial survey will entail costs for the route manager. Monitoring and management also entails costs for the manager. The innocent owners of plots along the line have no additional costs.	Additional costs for the farmer Limited costs for the government (processing data) if these samples are part of a monitoring measuring network.	The costs for the initial survey and possibly BBO with excavation lie with the applicant for the environmental permit.
Legal impact (decree changes, etc.)	**Legal impact (decree changes, etc.)**	**Legal impact (decree changes, etc.)**	**Legal impact (decree changes, etc.)**
The standard procedures should be amended/supplemented to clarify these obligations for a number of activities The VLAREBO makes it possible to tackle soil contamination by atmospheric deposition. Except that little attention is paid to it in practice.	Legislation change required to impose screening on route managers and to develop monitoring/management procedure. Changes may need to be made to avoid it being necessary to automatically proceed to a BBO and remediation/imposition of recommendations for use if an increased concentration is found in the measuring network. After all, contamination can potentially be "new" if upward trends emerge from the monitoring.	The soil decree must be amended to define the new category of land, and a separate procedure must be included for further survey after an increased concentration has been established. Possible impact on other regulations (manure policy) if samples are taken in combination. What if agricultural land turns out to be diffusely contaminated? Impact on public health? Authorizations?	Changes to various legislation required (soil decree, environmental permit decree).
What does this mean for the soil certificate?	**What does this mean for the soil certificate?**	**What does this mean for the soil certificate?**	**What does this mean for the soil certificate?**
If contamination is found, according to the current system, this will end up on the soil certificate of the surrounding plots → owners/buyers are therefore informed, also about any restrictions/recommendations for use that are imposed/recommended.	**See scenario 1b:** As long as the diffuse contamination has not been confirmed in a screening, a **specific statement** will be made on the soil certificate for the diffuse soils, stating that the soil may be diffuse contaminated and with which parameters, with a reference to the map/website. If diffuse contamination has been established, this can be stated as such on the soil certificate, together with any specifications (e.g. current management plan, usage recommendations and restrictions)	See scenario 1b: As long as the diffuse contamination has not been confirmed in a survey, a **specific statement** will be made on the soil certificate for the diffuse soils, stating that the soil may be diffuse contaminated and with which parameters, with a reference to the map/website. If diffuse contamination has been established, this can be stated as such on the soil certificate, together with any specifications (e.g. current management plan, usage recommendations and restrictions)	**See scenario 1A:** A **general sentence** is added to each soil certificate that it is always possible to check on a particular website whether the soil is potentially diffusely contaminated. If the contamination has been effectively established in a screening sample/OBO/BBO, the soil certificate can be prepared in its current form (no changes)
What preliminary steps are required to implement this scenario?	**What preliminary steps are required to implement this scenario?**	**What preliminary steps are required to implement this scenario?**	**What preliminary steps are required to implement this scenario?**
At least introduction of scenario 1a. An additional list must be prepared indicating the activities for which the survey of the surrounding plots must be carried out. This will have to be substantiated.	• Implementation of scenario 1a or b to indicate the potential diffuse soils. • Exploratory studies will be necessary to determine the route sections for which this is relevant (all roads? Only major roads? How big? Up to what distance from the route? Focus on specific land uses along the route (gardens? Agriculture?) • A lot of the pieces of land along line routes are public domain (e.g. verges). Can these be unambiguously included in the LIR? So that usage recommendations/restrictions can be linked?	• Preferential implementation of scenario 1b • Exploratory studies to demonstrate links between certain substances and agricultural soils are necessary; current relationships in this study are theoretical. More information is needed about which pesticides, antibiotics, etc. are relevant.	Implementation of at least scenario 1a so that soil remediation experts can check which suspect substances they should take into account.
Prevention	**Prevention**	**Prevention**	**Prevention**
Improved flue gas cleaning, imposing stricter standards for emissions to air	• Phasing out most polluting fuels (diesel trains and vehicles), • stimulating electric transport, • further regulate tyre composition	• Reducing pesticide use (organic farming) • Limiting manuring or taking into account the heavy metal content (see P and N in current manure policy),	• Attention to leaching in the development of (new) building materials • Further focus on campaigns such as "gezond uit eigen grond"(healthy from your own soil) (vegetable gardens

	• reduce pesticide use (banned since 2015, but still granted exceptions) • Develop water policy further so that uncontrolled flooding can be avoided. (see Integraalwaterbeleid.be) • Better shielding of gardens along certain line routes (hedges, screens ??)	• limiting the use of antibiotics and other pharmaceuticals in animal husbandry. • standardization for the composition of plastic films used in agriculture. Coordination/expansion of the analysis package of existing control systems (compost, sludge, manure, etc.) that can form the input of diffuse contamination to agricultural land	and chickens) and "zonder is gezonder" (without is healthier) (use of pesticides) • Further regulation of permitted pesticides, also for professional users (gardening contractors).
Raising awareness	**Raising awareness**	**Raising awareness**	**Raising awareness**
Experts need to be more aware of larger sources and their effects on their emissions in the wider area. Companies must also be more aware of atmospheric deposition and the diffuse soil contamination caused.	For sensitive land uses along such a line section, additional sensitization is indicated (e.g. growing vegetables, keeping chickens, playgrounds, etc.)	Introducing this will raise awareness among farmers about pesticides and manure use. Information campaigns may also be appropriate	Building owners will be made aware of potential soil contamination. Also when purchasing land (non-risk land) more attention will be paid to this, which can lead to more voluntary exploratory soil surveys before a piece of land is sold.
Benefits	**Benefits**	**benefits**	**Benefits**
• serious diffuse contamination in the vicinity of "larger" sources will be detected more quickly.	• the impact is estimated to be large, so this scenario can be tackled more quickly.	• the impact of diffuse contamination on agricultural land is estimated to be large, so further surveys are recommended.	• Gardens in residential areas are suspect locations for diffuse soil contamination with a relatively high impact because of various potential sources such as pesticides, the heating of buildings, open fires, the use of coal ash, embankments, etc. in view of the sensitive use, an approach is recommended.
Disadvantages	**Disadvantages**	**disadvantages**	**Disadvantages**
- The survey in the environment can take a longer time - which is disadvantageous for transfers, for example	• A screening on its own may not provide a complete picture. On the other hand, it is not realistic to survey all plots along line routes.	• These pieces of ground are currently not risk ground, little information is known about them • Creates an additional administrative and financial burden for farmers	• Additional costs for building plans for private individuals • Any contamination is only discovered when building plans are in place. Contaminants can therefore remain unnoticed for years to come. • Contaminated sites that have already been built on will not be dealt with or will only be dealt with in the very long term.
Comments	**Comments**	**Comments**	**Comments**
• This is really just a stricter application of the current procedures, atmospheric deposition already needs to be checked, but rarely happens. • Also corresponds to the concept of "nearby atmospheric pollution" as stated by Wallonia (the concept is only used there for research projects, not in policy)	• many of the diffuse soils along line routes will also be potentially diffusely contaminated due to other sources. An overlap can occur here between the different scenarios.	• Management and usage restrictions similar to the situation with ZM in France around Paris (only energy crops allowed) and PFAS in Germany (advice on which crops can be grown safely)	• Similar to Scandinavian countries: only when something happens on the ground (digging, change of use, etc.) does a survey start to determine whether the ground is suitable for the intended use. • Also similar to the Netherlands. The data obtained there is also used for the preparation of soil quality maps

next steps - specific approach around several themes			
= scenario 1 (indication of diffuse soils) + Focus on a few themes in order to map the most important diffuse contaminants (see the impact analysis study) more actively.			
5. Diffuse contamination as a result of demolition (infrastructure)	**6. Fires**	**7. Public areas and sports grounds**	**8. Sewer systems**
Objective	**Objective**	**Objective**	**Objective**
Tackling diffuse contamination as a result of demolition → analogous to theme 4 for environmental permits: If necessary, recommendations for use are imposed or a BBO with excavation can be carried out (see asbestos drip zones)	Tackling diffuse contamination as a result of fire. An approach analogous to the asbestos fires procedure can be applied here.	Tackling diffuse contamination in public areas (parks, cemeteries, etc.) and sports grounds. Mandatory sampling is imposed if there are indications of diffuse contamination. If contamination is found, the existing survey and remediation process can be followed.	Tackling diffuse contamination as a result of leaking sewer systems. Carrying out surveys when preparing a TV as part of planned sewerage work. Removing any contamination when carrying out sewerage works.
Survey obligation and inventory obligation	**Survey obligation and inventory obligation**	**Survey obligation and inventory obligation**	**Survey obligation and inventory obligation**
impose mandatory sampling after demolition of a building If elevated concentrations are found, an OBO must be prepared to determine whether it concerns a diffuse contamination over a large area or not	After a fire, a soil survey must be conducted in accordance with theme 1. This also means extending the asbestos fires procedure	impose mandatory sampling in accordance with scenario 1B	If sewerage is removed for renewal, sampling of the underlying soil is mandatory. This could be integrated into the procedure for the technical report. Sampling is currently limited to the depth of the sewer trench; this can be changed. This avoids having to take samples during the work and the work being delayed
Demarcation and Remediation obligation	**Demarcation and Remediation obligation**	**Demarcation and Remediation obligation**	**Demarcation and Remediation obligation**
If, after implementation of the OBO, it appears that it concerns diffuse contamination over a potentially large area, scenario 1B can be followed. The question remains as to who should organize and fund the further approach from scenario 1B. If it turns out that it concerns a very local diffuse contamination (e.g. local elevation, coal dust in gardens, etc.), a BBO with excavation can be carried out (see approach to asbestos drip zones).	Since this scenario focuses on areas where a link with the source can still be found, the current survey and remediation process can in principle be followed. See the claims procedure (and delimitation via BBO)	Can be done via the current arrangement	If it turns out that it concerns a very local diffuse contamination (e.g. local elevation, coal dust in gardens, etc.), a BBO with excavation can be carried out (see the approach to asbestos drip zones).
Cost	**Cost**	**Cost**	**Cost**
The costs for the initial survey and possibly BBO with excavation lie with the initiator of the demolition.	Owner/operator	High additional costs for owners and operators	Possible additional costs for sewerage works, risk of delay of work etc. and associated costs. These are borne by the sewerage manager.
Legal impact (decree changes, etc.)	**Legal impact (decree changes, etc.)**	**Legal impact (decree changes, etc.)**	**Legal impact (decree changes, etc.)**
Change in various legislation necessary (soil decree, demolition regulations)	Change in decree required.	See 1b	No change needed? Is this possible through the standard procedure TV? Or is an additional obligation to report contamination needed?
What does this mean for the soil certificate?	**What does this mean for the soil certificate?**	**What does this mean for the soil certificate?**	**What does this mean for the soil certificate?**
See scenario 1A: A **general sentence** is added to each soil certificate that it is always possible to check on a particular website whether the soil is potentially diffusely contaminated.	If contamination is found, according to the current system, this will end up on the soil certificate of the surrounding plots → owners/buyers are therefore informed, also about any restrictions/recommendations for use that are imposed/recommended.	See 1b	Sewage works are located on public land. No soil certificates are issued for this. If the contamination has spread to cadastral parcels, the information will end up on the certificate when the BBO is prepared in the usual way.

If the contamination has been effectively established in a screening sample/OBO/BBO, the soil certificate can be prepared in its current form (no changes)			
What preliminary steps are required to implement this scenario?	**What preliminary steps are required to implement this scenario?**	**What preliminary steps are required to implement this scenario?**	**What preliminary steps are required to implement this scenario?**
Implementation of at least scenario 1a so that soil remediation experts can check which suspect substances they should take into account.	A system must be set up to report fires to OVAM, possibly via the current claims procedure	Better substantiation of links between these locations and diffuse contamination	None
Raising awareness	**Raising awareness**	**Raising awareness**	**Raising awareness**
Building owners will be made aware of potential soil contamination. More attention may be paid to careful demolition	**/**	**See 1b**	Including the obligation in a TV will increase awareness.
Prevention	**Prevention**	**Prevention**	**prevention**
Careful demolition of buildings	General focus on fire prevention Development of environmentally friendly fire-fighting foams. Continue to focus on the asbestos reduction policy	Use of pesticides on public land has been banned since 2015. The exception requests should be limited.	Investing in sewerage infrastructure in Flanders.
Other benefits	**Other benefits**	**Other benefits**	**Other benefits**
/	/	/	Can simply be included in work already planned
Other drawbacks	**Other drawbacks**	**Other drawbacks**	**Other drawbacks**
• Additional costs for demolition • Any contamination is only discovered when it is being demolished. Contaminants can therefore remain undetected for years to come.	/	/	Many existing sewers are not removed but filled up during renewal. Then there is no or a less simple opportunity for remediation.
comments	**comments**	**comments**	**comments**
/	This is a supplement to the procedure for asbestos fires.	**/**	**/**

CONSULTATION NAME
Diffuse Soil Contamination Workshop

DATE MINUTES SENT
17/7/2020

DATE OF MEETING
19 June 2020

MEETING START TIME
10:00

MEETING END TIME
13:00

LOCATION
video conference

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Nele Bal	OVAM	
Bruno Billaert	OVAM	
Mike Mortelmans	OVAM	
Dirk Dedecker	OVAM	
Kaatje Touchant	VITO	
Johan Gemoets	VITO	
Vermeiren Karolien	VITO	
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Timothy Geerts	Grondwijzer	
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Janssen Nele	Aecom	
Panogiotis Gkorezis	Terracorrect	
Nathalie Severyns	Antea group	
Dominique Devos	Liedekerke advocaten	
Ruth Cartuyvels	Witteveen en Bos	

1. Introduction and positioning by Griet van Gestel - OVAM

2. Presentation of the participants

3. Explanation of the diffuse soil contamination study - Arcadis-Dorien Gorteman

See the attached presentation

Questions and Responses:

- When estimating the impact, were the risks arising from the contamination taken into account?
    - As far as possible: the substance properties (toxicity, persistence) and possible receptors (gardens, playgrounds, agricultural area vs. industrial estate, etc.) were included in the consideration when assigning the qualitative impact.

- For a large number of the diffuse soils mentioned, the source is identifiable (source plot) and there is therefore a survey/remediation obligation already. These should not really be considered to be diffuse. E.g. emissions from railways, the source is clear: namely the railway. Landfills aren't really diffuse either?
    - This will certainly be discussed in part 2 of the scenarios, the source is often clear, but this is seldom investigated, the current set of instruments does not seem to sufficiently overcome this (railways are not risk ground)
    - in addition to landfills, waste can also generally mean the improper handling of waste, as has sometimes happened in the past.

- For example, was the deposition of nitrates over the entire area included in the atmospheric deposition? What leads to over-fertilization throughout Flanders? Or was this out of scope?

- At the roadsides: was the use of road salts (containing cyanides) also included?

- Also possibly diffusely contaminated: the old maintenance paths along the railways. During the coal-fired locomotive period, so for about 100 years, the combustion ash (heavy metals, PAH) was scattered over those paths because of its stability and the weed-suppressing character.

4. Explenation of the policy scenario

4.1 step 1: explanation of scenarios indicating diffuse soils

See the attached presentation

Discussion/questions:

- The TV and OBO are discussed a lot in the explanation, will the obligations then mainly lie with the owners?

- What is meant by contamination by diffuse ground? Exceeding target value? Seems on the strict side, because this will be exceeded in many areas + in many areas that are being remediated, concentration will remain above GV. The guideline value is exceeded in 50% of the technical reports.

- can different scenarios also be split up? For example, one scenario for one type of ground, other types of ground better through another scenario?

Poll: which scenario do you prefer?

- Scenario A: 9
- Scenario B:12
- Scenario C: 0

4.2 step 2 - explanation of scenarios and practical elaboration per theme

See the attached presentation

Discussion/questions:

- What will be the costs for, for example, taking and analysing a sample in an agricultural area or when applying for a permit?
    - This will depend on the result and policy that is associated with it. Is it the intention of the policy to measure in order to know and to inform? Or also other steps? Will always be a consideration of costs versus benefits/impact. Cost will play a role in policy development.

- in many gardens the GV will be exceeded and therefore end up in the OBO procedure. Can consideration be given to whether different standards can be used for diffuse? Maybe build/expand SGEI differently with a procedure for diffuse? So that there is a different outcome than a whole OBO/BBO immediately? Policy development will have to be tailored to each theme/problem.

- approach in the scenarios is very strongly ground-based. This has already been partly included in the decree. Is it not appropriate to involve the sector organisations as well? For example, for the farmers? It would be helpful if the sector organisations could take the lead and this is not something that the individual farmer has to take on.
    - That is certainly the intention, we also want to make the benefits clear for users and owners so that farmers are also informed about the quality of their land and can also protect themselves against situations where, for example, pieces of ground are raised with contaminated material

Poll: which of the themes do you consider to have the highest priority?

- Theme 1: contamination can be linked to a major source: 5
- Theme 2: Line routes: 2
- Theme 3: agricultural land: 7
- Theme 4: “sensitive” soils without risk activities: 7

5. Discussion

- Careful consideration must be given to what to do with the diffuse contamination found.
    - If there is no remediation or consequences associated with them, which survey efforts are worthwhile for the benefit of the survey? Large-scale studies that show that remediation is not BATNEEC are of little use
    - Aim for the target well. For example railways and the surroundings areas: if there are no receptors along large areas, should you investigate them? Better focus on railways through residential areas, for example.
    - Intermediate steps will be taken with exploratory studies to see whether there is an effective impact from railways.
    - Priorities can also be set within each category or theme: e.g. only include gardens along railways in policy first.
    - Parameters to be studied can also be prioritized.
    - On the other hand, sampling is usually the biggest cost, so it can be interesting to include as many parameters as possible when taking samples. For example, in the case of samples taken by farmers in connection with manure policy: cannot OVAM analyse additional parameters in the first study on those samples that are nevertheless taken?
    - Other organisations also collect samples in vegetable gardens, in meadows, etc. In the first workshop with data managers there were also contacts with, for example, the soil science service, VLM, etc.

- in these themes too there are still many links with the current decree: make sure that no existing policy instruments/processes are crossed, for example, line route: banks: also falls under sediment policy. Make sure that nothing is caught twice.
    - In this study, a broad inventory of diffuse contamination was deliberately chosen because on the one hand the existing instruments already cover part of the diffuse problems, but for a number of aspects the instruments proved insufficient. For example, the theme of the large sources/atmospheric deposition: is, strictly speaking, already in the procedure, but not much surveyed/detected → so existing instruments must be optimized. This also

offers opportunities for sediment, for example, where the instruments are under development to take diffuse contamination into account.

- The participation of the various actors was very important in the development of the policy and approach to sediment. This will be the same when tackling this problem.
- For example, you can map atmospheric deposition in a very model-based manner, which provides a more objective basis on which to base policy. This can be combined with validation in the field.
- note on the preventive approach: currently the CVGP for soil remediation centres is being revised, diffuse contamination should also be kept in mind when adapting such codes.
- Drip zones may not fall directly under diffuse contamination, but they do concern contamination on non-risk ground. I think that the experiences are relevant for further elaboration of diffuse contamination?
- scenario 4 feels contradictory to the exemption from the preparation of a TV for volumes below 250 m³. On the other hand, if you are going to live somewhere, it can also be useful to know the quality of the soil there.
- in the past there have been discussions about introducing a survey obligation when applying for a permit. But then this only related to permits for risk ground?

6. Agreements and outlook

Feedback/comments Questions may certainly be passed on, preferably before 21/8/2020.

Appendices
workshop presentation
document discussion paper policy scenarios
tables with an estimate of the impact of diffuse soil contamination