

Inventory of awareness, approaches and policy

Insight in emerging contaminants in Europe

Ministry of Infrastructure and Environment, the Netherlands
Public Waste Agency of Flanders, Belgium

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Project leader	M. van Houten BSc
Project director	W. Hendriks MSc

Author(s)	Dr. P.A. Alphenaar MSc, M. van Houten BSc
Checked by	W. Hendriks MSc
Approved by	M. van Houten BSc

Initials



Address	Witteveen+Bos Raadgevende ingenieurs B.V. Van Twickelostraat 2 P.O. Box 233 7400 AE Deventer The Netherlands +31 (0)570 69 79 11 www.witteveenbos.com KvK 38020751
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TTE Consultants
Keizerstraat 16
7411 HH Deventer
The Netherlands
+31 (0)570 66 58 70

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SUMMARY

The group of Emerging Contaminants (EC) is very diverse, for example in terms of toxicity, behaviour and waste water treatment or remediation techniques. The last decade more than 2100 scientific studies have shown that EC pose a potential risk to humans, plants and/or animals. There is, however, a lack of knowledge about the factual situation and risks in the soil, sediment and groundwater system. Also the policy approaches in different countries are not well known. Hence the scale of the environmental problem caused by these contaminants in soil, groundwater and sediments is unclear.

What are emerging contaminants?

US Geological Survey¹: *any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects.*

NORMAN Network Europe² makes a difference between emerging substances and emerging pollutants. *Emerging substances can be defined as substances that have been detected in the environment, but which are currently not included in routine monitoring programmes at EU level and whose fate, behaviour and (eco)toxicological effects are not well understood.*

Emerging pollutants can be defined as pollutants that are currently not included in routine monitoring programmes at the European level and which may be candidates for future regulation, depending on research on their (eco)toxicity, potential health effects and public perception and on monitoring data regarding their occurrence in the various environmental compartments.

This study is focuses on man-made EC which are already present in the compartments of the soil, groundwater and sediment.

There is a lot of scientific information regarding the chemistry, toxicity and fate of EC. Several international scientific networks, for example the European NORMAN Network, summarized and interpreted all this information and share this on their website. . The knowledge from these networks could be used to prioritize data collection and environmental monitoring. The political prioritization of the prioritized substances, based on their toxicity and environmental hazards, is defined in the Stockholm Convention on Persistent Organic Pollutants (POPs). For all other EC it applies that the lack of understanding the effects and the lack of factual data in soil, groundwater and sediment are by far the main obstacle to develop a practical approach [Maria Gavrilescu et al³].

Generally, the soil and groundwater system responds slowly. Therefore the effects of EC will be notable in the long run. In the mean time irreversible damage may be caused that will affect our resources and natural environment. Similar to the actions that were taken in order to secure our fresh water system, it is time to address the problem that causes EC and take further actions for our soil system.

¹ Website United States Geological Survey: <http://www.toxics.usgs.gov/regional/emc/>.

² Norman Network: <http://www.norman-network.net>. The NORMAN network is a permanent self-sustaining network (EU) of reference laboratories, research centres and related organisations for the monitoring and biomonitoring of emerging environmental substances. It enhances the exchange of information on emerging environmental substances, and encourages the validation and harmonisation of common measurement methods and monitoring tools so that the requirements of risk assessors and risk managers can be better met.

³ Maria Gavrilescu et al, Emerging pollutants in the environment: present and future challenges in biomonitoring, ecological risks and bioremediation, January 2014, New Biotechnology

To wrap up available knowledge and experience related to legislation, governance and policy in the European Union, a website and questionnaire was made and a search on relevant literature has been carried out. The website had over 3.200 visitors between May and October 2015. Over more than 500 experts in the field of soil, groundwater and sediment in Europe were asked to fill in the questionnaire. We received 12 questionnaires and some information was uploaded. Based only on the response to the questionnaire, our conclusion was that the topic 'EC' in soil groundwater and sediments is too complex for the transfer of knowledge by a website and/or questionnaire. In other words: we suppose that more information is available, but we didn't get this information with our approach. In contrast to the limited response to the questionnaire, a lot of support and information was gained during the international meetings and a literature assessment. Still this study is not a complete overview of all available literature and data on EC.

Many POPs are EC and many EC are POPs^{1 2}

Emerging contaminants and other substances that have no regulatory standard, but have been recently discovered in natural streams and may damage aquatic life and human health. They are pollutants not currently included in routine monitoring programs and may be candidates for future regulation. Persistence and organic are among the key features of EC. This is why many POPs are an EC. Based on the original application and function of these substances, the next detailed classification for EC is used:

- *Persistent organic pollutants (POPs)* are toxic chemicals that originate from man-made sources associated with the production, use, and disposal of certain organic chemicals.
- *Pharmaceuticals and personal care products (PPCPs)*, include any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock.
- *Endocrine-disrupting chemicals (EDCs)*, including synthetic estrogens and androgens, naturally occurring estrogens, and other chemicals that affect hormonal functions.
- *Nanomaterials* or nano-scale particulate titanium dioxide.

The main conclusion of the inventory we have carried out is that EU member states should work together to develop the best approach for EC in soil, groundwater and sediments. Based on a joint strategy to share knowledge and expertise, it is most effective to work together on an international level with all stakeholders. This gives the advantage of commitment from all stakeholders.

Determining where and in what concentrations ECs are present in the soil, groundwater and sediment should be the first step to get a better overview about the extent of this topic. This step should give also the answer to questions as: Which ECs are relevant for our country or region? Where are possible sources and what are the pathways of ECs in soil, groundwater. Subsequently the true environmental and human risks can be determined with the results of this step. Adequate strategies and effective solutions can only be developed when this practical information is available. Based on expert judgment it is expected that the risks are most acute near contaminated hotspots. Those hotspots are easier to remediate or to manage, instead of plumes with contaminated groundwater. Based on this inventory our opinion is to focus on an (international) approach initially.

In the future new EC will arise. The Stockholm Convention lists new substances every two years. An approach for the management of EC in soil, groundwater and sediments can be based on the experience and work of scientific research and the decisions of institutes like the Stockholm Convention or Norman Network.

¹ Contaminated site Clean-Up information: <https://clu-in.org>

² Portal for soil and water management in Europe: <http://www.eugris.info>

INTRODUCTION

With increasing frequency countries and organisations are faced with chemicals that have not been considered as 'contaminants' before. Some of these chemicals could be a potential risk to humans and/or the environment. These are the so-called 'Emerging Contaminants' (EC). Roughly defined by the United States Geological Survey¹ as: *'any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects.'* Other organisations like US EPA, NORMAN Network or the UN-EP gives a more or less similar definition (see below).

What are emerging contaminants?

US Geological Survey²: *any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects.*

NORMAN Network Europe³ makes a difference between emerging substances and emerging pollutants. *Emerging substances can be defined as substances that have been detected in the environment, but which are currently not included in routine monitoring programmes at EU level and whose fate, behaviour and (eco)toxicological effects are not well understood.*

Emerging pollutants can be defined as pollutants that are currently not included in routine monitoring programmes at the European level and which may be candidates for future regulation, depending on research on their (eco)toxicity, potential health effects and public perception and on monitoring data regarding their occurrence in the various environmental compartments.

The group of EC consist of substances which significantly vary in terms of toxicity, behaviour, remediation/treatment technique and so on. The similarity between all the substances is a lack of awareness and strategy. This leads to the following problem definition given by Maria Gavrilescu et al⁴. *'Emerging pollutants reach the environment from various anthropogenic sources and are distributed throughout environmental matrices. Although great advances have been made in the detection and analysis of trace pollutants during recent decades, due to the continued development and refinement of specific techniques, a wide array of undetected contaminants of emerging environmental concern need to be identified and quantified in various environmental components and biological tissues. These pollutants may be mobile and persistent in air, water, soil, sediments and ecological receptors even at low concentrations.'*

¹ website United States Geological Survey: <http://www.toxics.usgs.gov/regional/emc/>

² Website United States Geological Survey: <http://www.toxics.usgs.gov/regional/emc/>.

³ Norman Network: <http://www.norman-network.net>. The NORMAN network is a permanent self-sustaining network (EU) of reference laboratories, research centres and related organisations for the monitoring and biomonitoring of emerging environmental substances. It enhances the exchange of information on emerging environmental substances, and encourages the validation and harmonisation of common measurement methods and monitoring tools so that the requirements of risk assessors and risk managers can be better met.

⁴ Maria Gavrilescu et al, Emerging pollutants in the environment: present and future challenges in biomonitoring, ecological risks and bioremediation, January 2014, New Biotechnology

Robust data on their fate and behaviour in the environment, as well as on threats to ecological and human health, are still lacking. Moreover, the ecotoxicological significance of some emerging micro pollutants remains largely unknown, because satisfactory data to determine their risk often do not exist.'

This article is enclosed in appendix I.

This report describes the conclusions of an inventory on awareness and policy on Emerging Contaminants in Europe. The aim of this study is to identify approaches related to legislation, governance, techniques and policy. It strongly focuses on the presence of Emerging Contaminants in soil, groundwater and sediment. Therefore this inventory is only on the curative policy and not on prevention.

The study was commissioned by the Ministry of Infrastructure and Environment (IenM) in the Netherlands and the Public Waste Agency of Flanders (OVAM) in Belgium. A study on Emerging Contaminants and the awareness and policy have been conducted using various methods like interviews, a questionnaire and a literature assessment. This report gives the insights that have been obtained, with respect to the policy and approaches on Emerging Contaminants in Europe. This study is not an overview of all available literature and data on EC. It is clear this topic is actual but also very broad with different discussions, opinions and point of views. The enclosing remarks can be used for further actions.

1.1 Emerging contaminants and Persistent Organic Pollutants

Because the improved detection methods 'new' substances have been discovered in natural streams. These substances may damage aquatic life and human health. Persistence and organic are among the key features of these substances. That's why many persistent organic pollutants (POPs) are also classified as an EC.^{1 2}

On the basis of the original application of the substances a more detailed classification for EC is used:

- *Persistent organic pollutants (POPs)* are toxic chemicals that originate from man-made sources associated with the production, use, and disposal of certain organic chemicals. Some of the POPs such as pesticides and polychlorinated biphenyls (PCBs) are intentionally produced, while others such as dioxin and furans are unintentional by-products of industrial processes or result from the combustion of organic chemicals.
- *Pharmaceuticals and personal care products (PPCPs)*, include any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock. PPCPs comprise a diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, sunscreens, detergents, and cosmetics.
- *Endocrine-disrupting chemicals (EDCs)*, including synthetic estrogens and androgens, naturally occurring estrogens, and other chemicals that affect hormonal functions.
- *Nanomaterials*, such as carbon nanotubes, or nano-scale particulate titanium dioxide used in sunscreens, cosmetics, paints and coatings.

1.2 Objectives

The aim of this inventory is to wrap up available knowledge, experience and awareness related to legislation, governance and policy. It focuses on the presence and the curative policy on EC that are already present in the soil, groundwater and sediments. Because the term 'Emerging Contaminants' is used as a concept for an extensive group of parameters, this inventory also focused on PFOS and PFOA as a representative example of EC.

¹ Contaminated site Clean-Up information: <https://clu-in.org>

² Portal for soil and water management in Europe: <http://www.eugris.info>

The inventory on available knowledge and experience is carried out on two separate tracks.

- A questionnaire and a website as a platform for exchanging information and collecting data was drawn up. The questionnaire is distributed among all the members of the EU Common Forum and the members of the related network organisations SedNet and NICOLE. Approximately 500 people were asked to fill in the questionnaire. Also several presentations at international symposia were given, like the Common Forum meeting in Copenhagen, the 'emerging and unconventional contaminants' meeting from NICOLE in Manchester, the ICCL meeting in Australia and the SedNet meeting in Poland. Also poster presentations were given at AquaConSoil 2015 and at the Global Soil week 2015. In addition we interviewed approximately 25 colleagues in Australia, United States of America, Norway, Swiss and Asia.
- A literature assessment is carried out. At first, based on an intensive internet search and later on extended with the use of reports, articles, presentations and references which were obtained as a result of the questionnaire, interviews, website activities and presentations. Also the preliminary results of the survey from the members of Common Forum/EU Member States, members of NICOLE and members of SedNet are used.

This study focuses on EC that are already present in the soil, groundwater and sediments. Also this is only about the curative policy and legislation and not about preventive legislation nor about the application of EC. The preventive legislation in Europe is based on REACH legislation. Since PFOS and PFOA appears to be one of the most well-known EC, we paid special attention on those compounds as a pilot to illustrate the issues of emerging contaminant.

PROBLEM DEFINITION

The current approach to deal with contaminations in soil, groundwater and sediment is mainly focused on heavy metals and the common organic contaminants (TPH, PAH's, BTEX and chlorinated solvents). Although in the past we were faced with a "new" pollution occasionally (e.g. in the 80s with PCBs, in the 90s with dioxins and MTBE in the early years of this millennium) up till now there was no need to adjust the policy, legislation or conventional approach for the management of contaminations in soil, groundwater and sediments. The vast majority of the known problems were effectively addressed. This report gives the insights that have been obtained, with respect to the policy and approaches on Emerging Contaminants in Europe.

2.1 An uncomfortable truth

During the last decade we increasingly realized that there is a great number of less common industrial chemicals, pesticides, drugs, hormones and nano-particles which are potentially harmful and which may cause an environmental problem. At the time we thought that the soil contamination problem was under control (and the remediation program in the Netherlands could be completed). The inconvenient truth, however, is that the environmental risks (defined by the product of the toxicity, quantity and exposure) associated with these 'new' compounds are not well known or understood, but may be severe. Sadly inconvenient truths are often ignored rather than faced, for example the global climate change discussions.

An example of the discussion on EC is about PFOS (perfluorooctane sulfonate) and PFOA (perfluorooctane sulfonic acid) which are the primary compounds of the 'Poly and Per Fluor Alkylated Substances (PFAS) group. In the early 2000 3M stopped producing PFOS and using it in their products because of the toxicological risks. Moreover, these compounds were listed as 'Annex B substances' at the Stockholm Convention in 2009¹ (see text box). This decision means that these substances need further measures to restrict the production and use. Regulatory exemptions for specific applications have to be reconsidered. Until today the actual appearance (and threats) of PFAS are unclear but it is for sure that these substances are present in our environment. The way we deal with this is an example of our approach on emerging contaminants.

The lack of knowledge causes a chain of uncertainty which hampers the development of specific policies and efficient remediation techniques:

- Scientific programs for EC focus mainly on risks and toxic effects in fresh and marine waters and our food chain (due to the Water Framework Directive). Much less attention is paid to the soil and groundwater. This may be because there is no EU direction for soil and sediments.
- There is little knowledge the risks involved with EC since they are rarely analysed in soils, sediments and groundwater.
- Since there are no evident risks or dangers, there is neither political drive nor money to create specific policy or legislation.

¹ <http://chm.pops.int/Convention/Pressrelease/COP4Geneva8May2009/tabid/542/language/en-US/Default.aspx>

² <http://chm.pops.int/Portals/0/Repository/COP4/UNEP-POPS-COP.4-38.English.pdf>

- The lack of specific legislation hampers development of adequate strategies and technologies. This development is necessary to control or remediate existing contaminants in soil, groundwater or sediments.
- Uncertainty about legal and financial consequences and the resulting lack of technical solutions will hamper an efficient approach and spatial development.

Stockholm Convention on Persistent Organic Pollutants

The Stockholm Convention on Persistent Organic Pollutants is an international environmental treaty, signed in 2001 and effective from May 2004. This convention aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). Key elements of the Convention include the requirement that developed countries provide new and additional financial resources and measures to eliminate production and use of intentionally produced POPs, eliminate unintentionally produced POPs where feasible, and manage and dispose of POPs wastes in an environmentally sound manner. Precaution is exercised throughout the Stockholm Convention, with specific references in the preamble, the objective, and the provision on identifying new POPs. May 2013, there are 179 parties to the Convention (178 states and the European Union). Notable non-ratifying states include the United States, Israel, Malaysia, Italy and Iraq. Most of the decisions of the Stockholm Convention are also adopted to EU legislation.

2.2 Unknown and undetected

Although there is a large amount of knowledge in the world (especially in the USA and Australia) there is no formal initiative or program in the EU on how to deal with EC in soil, groundwater and sediments. Sharing knowledge and experience between policy makers and scientists is still very limited in the EU¹ on the topic of EC. Hence the general scale of the contamination is unclear. Moreover it is unknown where the main contaminated sites are and which substances are most dominant at those sites. Even if this information is available the treatment of EC is still complicated since the remedial techniques are still in a phase of development. The described lack of accessible theoretical and practical information leads to stagnation in policy development. This may cause potential health risks and environmental risks. This study gives insight in the developed awareness and the policy and legislation about EC in the EU. Based on the results of our study we suggest what can be done to change the approach of EC in soil, groundwater and sediments in Europe.

¹ Maria Gavrilescu et al, Emerging pollutants in the environment: present and future challenges in biomonitoring, ecological risks and bioremediation, January 2014, New Biotechnology.

METHODOLOGY

3.1 Initial setup

The inducement for this report was the growing awareness for EC in the Water Framework Directive and the possible influence that EC have on surface water and drinking water. The Ministry of Infrastructure and the Environment in the Netherlands and the Public Waste Agency of Flanders (OVAM) in Belgium asked themselves how to deal with EC in soil, groundwater and sediments. These organisations wanted to know what experience other EU member states had with regard to these substances.

The question about EC is too generic to tackle in a single study with a limited size. Therefore, in order to prevent doing rework, an inventory of the awareness and the policy on EC in the EU countries was started. In order to do this the following steps were carried out:

- 1 In close consultation with the Dutch and Flemish members of the Common Forum on Contaminated Land in Europe¹, a questionnaire has been developed. Through this questionnaire all the Common Forum members were asked on their knowledge and awareness on EC in general, and PFOS and PFOA issues in particular. Although the focus of the questionnaire was on policy and awareness, it was decided to identify all aspects. The questionnaire has therefore become elaborate.
- 2 An interactive website was created in which the results of the survey is published and where the various Common Forum partners can upload their specific (policy) documents related to EC in general and to specific compounds like PFOS and PFOA. The website can still be used as a platform to exchange information and share knowledge. The results of the inventory are also published on this website.
- 3 The initial setup and the results of the inventory were discussed on international events like the Common Forum meeting (May 2015), AquaConsoil (May 2015), NICOLE meeting (June 2015), SedNet meeting (September 2015) and the ICCL meeting (September 2015). This has increased the awareness on EC in Europe.

3.2 Adjustments in progress

The questionnaire was sent to about 500 experts in Europe, Canada, Australia and the United States of America. The response to the 12 routed questionnaires was however low. The questionnaire itself illustrates the problem with EC: this topic is too large to be addressed in one simple format and to diffuse to hold the attention. But in conjunction with the substantial answers the response can, however, be considered as a result: the awareness is limited and there are hardly any specific policies or strategies.

To further substantiate the first impression about the awareness we started an assessment of literature found on the internet. In the presentations, interviews and in the subsequent discussions is searched and asked for additional background with respect to the (lack of) awareness.

Based on a very wide range of sources (scientific articles, presentations, 'gray' literature and policy studies) an image of the EC issues is created that differs from the usual approach for environmental problems.

¹ <http://www.commonforum.eu/>

This insight differs from the usual regular process¹ which often concludes that there is insufficient scientific knowledge and information. Based on our analysis, an initial sketch could be given about how the impasse regarding the approach of the EC in the EU could be broken.

During interviews and/or discussions we expressly asked about the observed (lack of) awareness regarding EC. Next to that we also asked for any additional information. We reviewed a wealth of sources (scientific articles, presentations, gray literature and policy studies) and focussed primarily on policy and awareness.

Based on our expert judgement we made a relationship between the literature and the answers from the questionnaire. Therefore all the information we used is available via the website². Everybody can use this information to draw their own conclusions and develop their own strategy. The website will kept be open as a platform for the exchange of knowledge and as a place to discuss about topics with a relation to EC.

¹ Regular process or approach for environmental problems: observation of a practical problem → research → policy → legislation/standards → technical development of analyses or treatment techniques → remediation → management.

² <http://www.emergingcontaminants.eu>

4

RESULTS

In this chapter the results of this project are described. Paragraph 4.1 provides a summary and interpretation of the completed questionnaires. The questionnaires themselves are enclosed in appendix II entirety, if we received permission to publish the answers. Paragraph 4.2 describes the statistics of the website from the start (April 1, 2015) until the possibility to upload information was closed (October 15, 2015). In paragraph 4.3 we briefly discuss the additional literature reviews carried out. The insights are given in paragraph 4.4 the discussion is subsequently described in chapter 5.

4.1 Results questionnaire

Definition

All participants of the questionnaire endorse the United States Geological Survey definition of EC: “any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects”.

CRC Care (Australia) adds as a comment: ‘existing (known) contaminants whose adverse impacts are becoming known (emerging), new contaminants whose (adverse) impacts are emerging’.

Awareness

The Stockholm Convention has established which POPs (persistent organic pollutants) should be considered as the most harmful components to humans and environment. Nowadays they listed 30 substances/groups (see table 4.1). This table shows how many experts are familiar with these substances (based on the questionnaire). Apart from the well-known substances such as DDT, Lindane and PCBs the familiarity of experts with these substances is limited.

Table 4.1 Familiar with Stockholm Convention contaminants

	Compound mentioned as known*	Compound	Compound mentioned as known *
aldrin	4	Lindane	7
bromobiphenylethers	1	Mirex	1
chlordane	2	Pentachlorobenzene	3
chlordecone	0	PCB	9
hcbd	0	SCCPs	1
Dicofol	0	Technical Endosulfan	1
Dieldrin	4	Tetrabromodiphenylether	1

	Compound mentioned as known*	Compound	Compound mentioned as known *
Endrin	2	Toxaphene	0
Heptachlor	2	DDT	7
Hexabromobiphenyl	0	PFOS and/or PFOA	5
Hexabromodiphenylether	0	PCP	4
HCB	4	PCDD	4
Hexachlorobutadiene	1	PCDF	4
Alphahexachlorocyclohexane	1	Polychlorinated Naphthalenes	3
Betahexachlorocyclohexane	1	PeCB	2

* total responds = 12

United Nations Environment Programme (UNEP)

The Stockholm Convention on Persistent Organic Pollutants was adopted on 22 May 2001 and entered into force on 17 May 2004. Being aware that persistent organic pollutants (POPs) pose major and increasing threats to human health and the environment, the Governing Council of UNEP requested in 1995 that an international assessment process be undertaken of an initial list of 12 POPs and that the Intergovernmental Forum on Chemical Safety (IFCS) develop recommendations on international action for consideration by UNEP Governing Council and World Health Assembly. The IFCS concluded that available information was sufficient to demonstrate that international action, including a global legally binding instrument, was required to minimize the risks from the 12 POPs through measures to reduce and/or eliminate their emissions or discharges. Based on this conclusion, the UNEP Governing Council invited UNEP to prepare and convene an intergovernmental negotiating committee (INC), with a mandate to prepare an international legally binding instrument for implementing international action initially beginning with the 12 POPs. They also requested that the INC establish an expert group to develop criteria and a procedure for identifying additional POPs as candidates for future international action. This INC became the Convention that was adopted and opened for signature in May 2001 in Stockholm, Sweden.

Any Party may submit proposal for listing a new chemical of the Convention. The POPs Review Committee evaluates the proposals and makes recommendation to the Conference of the Parties on such listing in accordance with Article 8 of the Convention.

More information about the role, rules and procedures of the Stockholm Convention are given on their website: <http://chm.pops.int/default.aspx>

Determining the priority

It also asked which other EC (besides the listed POPs from the Stockholm Convention) deserve attention or actually get in the approach/approach to soil, ground water and/or sediments.

Most participants indicated that special attention should be paid to TPH, asbestos, chlorinated compounds and heavy metals. Most attention therefore goes to the 'classic' pollutants.

Table 4.2 Other Emerging Contaminants with special attention

Compound	Countries (total = 8)	Compound	Countries (total = 8)
TPH (mineral oil)	6	chlorinated_solvents	8
hormones	2	MTBE	4
asbestos	6	dioxanes	3
heavy_metals	8	antibiotics	0
		Other: pesticides	2
		chloroparaffin	1
		nano particles	1

The answer to these questions reflects the challenge of EC. The standard substances receive attention because they are known to be toxic, there is legislation and there are standards for these substances and they are regularly monitored. This makes it easy to focus on the soil, groundwater and sediment. However, as indicated by one of the participants, these substances therefore are not EC anymore.

At the same time the participants indicated that attention should be paid to dioxins, PCBs, PCDDs, DDT, DDD, DDE and other substances with possible risks (eggs and chickens in private gardens).

PFOS/PFOA/PFAS

Only four EU countries indicate that they are directly confronted with PFOS/PFOA issues in soil, sediments or groundwater, three give some information about the PFOS sources:

- Belgium (Flanders): PFOS is surveyed on 'suspicious' sites
- Denmark: PFOS at airports, fire fighting stations, carpet industry, chromium plating, landfills
- Italy: factory of fluoropolymers.

This result indicates different phenomena [own interpretation]:

- PFOS/PFOA is just one of the many relevant EC which could or should be investigated
- There are less practical details known about PFOS or PFOA
- The known locations are not (yet) considered as a bottleneck in most countries.

Problems in practice

All participants indicated that they are faced with soil and groundwater problems related to EC. Although pesticides, dioxins and PCM's are specifically mentioned as EC, 'regular' pollutants like chlorinated solvents, mineral oil, heavy metals, historical pollution are more often discussed. There is a focus on PFOS/PFCs at production facilities and fire fighting places. One reaction summarizes the whole discussion: 'The problem is difficult to describe. Effects of contaminants are often unclear or not even present. The legislation typifies the presence of contaminants as a problem'.

There is less attention for sediments. It is also indicated here that it is difficult to find a relation between the occurrence of a substance and its effects. With regard to that substances mentioned are DDD, DDT and PCB's called. Other contaminants like pesticides, hormones, endorines, micropollutants and PFOS are mentioned in relation to surface water, waste and wastewater, which are important sources for POPs in the environment.

Policy and legislation related to EC

Nearly all participants indicated that soil and groundwater investigation is limited to a standard package. This package consists of heavy metals, TPH, BTEXN, PAHs and chlorinated solvents. Based on the site history the standard package can be extended with a specific analysis. It cannot be deduced whether a screening of the site specific substances/risk is part of the standard procedure.

From various conversations and experiences can be deduced that choosing whether or not a site should undergo specific analysis is often a subjective decision. One example on dealing with unknown substances is Denmark. In this country there are guidelines for handling substances with unknown toxicity and fate in relation to industrial activities. For example, when PFOS or PFOA are observed in Denmark the site is registered as contaminated and P&T will be applied. In Italy the spatial distribution of the contaminants has to be monitored and Flanders also has a specific procedure for the execution of a soil survey when PFOS or PFOA are detected.

Several contributors indicated that the policy on EC needs to be developed (further). They also indicate its development is not a priority of the legislators. Because there is a lack of time and budget the remediation of known pollutants is prioritized. Due to the lack of knowledge on EC policy makers fear uncontrollable costs. Freeing up money to make policy is difficult, but freeing up money to implement that policy is another story. (Too) high ambition seems to hamper working towards an effective approach or strategy for dealing with EC issues.

It is clear that, in order to convince policymakers, the problem should be manageable and solvable. Therefore it is suggested that there should be a list of prioritized EC and their possible sources. These sources should be well defined, and could consist of, among others: hotspots, diffuse pollution and accumulation spots. This clear information may force a breakthrough in EC policy. It is however also stated that policy (makers) does not use the current scientific knowledge on EC.

The submitted questionnaires showed that Belgium, Denmark, Lithuania, the Netherlands and Switzerland have legislation for EC in soil, groundwater and sediment. The policy is 'case directed' and the objective is to eliminate, reduce or manage risks due to soil and groundwater contamination. However, there is no policy or legislation on diffusely distributed EC. Unintentionally, this policy creates a lack of awareness and a 'not knowing what to do' approach on EC.

The Flemish policy is worked out most clearly, Vlarebo defines standards for various pollutants according to the intended use of the soil and groundwater, Vlarma does the same for waste recycling. To determinate the risks due to the contamination, a location specified threshold value needs to be calculated to. If risks (bases on the risk evaluation) are not being excluded, measures have to be taken to eliminate or reduce risks. The Dutch policy for contaminants indifferent environmental compartments states that it aims at prevention or mitigation.

Remediation and containment

Little concrete information related to remediation possibilities is gained through the questionnaire. Known approaches focus on chlorinated solvents, oil products, heavy metals, pesticides and cyanides. There are no special treatment techniques for EC. Excavation and pump and treat are mentioned, but especially for diffuse contaminations, these methods are not cost effective. To investigate the possibilities to tackle PFOS/PFOA issue, a large number of consultancies, technology developers and contractors have been consulted in the Netherlands. PFOS may be considered as a benchmark for EC as a whole.

Possible techniques

There is limited experience with remediation (removal) of PFOS contaminations. All known full-scale remediation or management approaches are based on the pump and treat method. The market indicates that the remediation efficiency of the regularly used treatment techniques at lower concentrations is unknown. There is need for lab and/or field tests to test the feasibility of potential remediation techniques.

Excavation is the only proven removal technique. The excavated soil should be cleaned (very difficult) or brought to a controlled landfill (acceptance is far from certain).

Pump and treat is applied as a control technique for the saturated zone. It is doubtful that pump and treat will lead to a finite remediation. Research is needed to determine until which concentrations remediation can be achieved with this technique.

Soil Washing is another possible remediation technique. Hereby excavated soil can be washed in a mobile installation". It is expected that PFOS partly adheres to the smallest particles and partially dissolves in the process water. The cleaned sand can be reused; the contaminated residual fraction (down to a tenths of a percent of the original volume) must be deposited or treated. Soil washing is a proven technology for sandy soils, but has never been used for PFOS in the Netherlands up until now. To determine the feasibility of this technique further research into its efficiency and cost is needed.

Thermal treatment. PFOS is broken only at very high temperatures (1200 °C), so cleaning is difficult and expensive. In-situ or onsite treatment is impossible.

Chemical oxidation. Some players suggest that PFOS treatment is possible with combinations of existing oxidation techniques remediation. Other parties describe these techniques as insufficient. Recently, two oxidation techniques (Perozone 3.0 and ScissoR) have been developed specifically for the rehabilitation of PFOS. Both are applicable to the saturated zone in-situ. There is uncertainty about harmful intermediates and/or residual products during oxidation.

Other techniques. In view of the properties of PFOS, biological degradation, air sparging/soil vapour extraction, thermal in-situ techniques, and all the other above-mentioned solutions are not considered to be feasible.

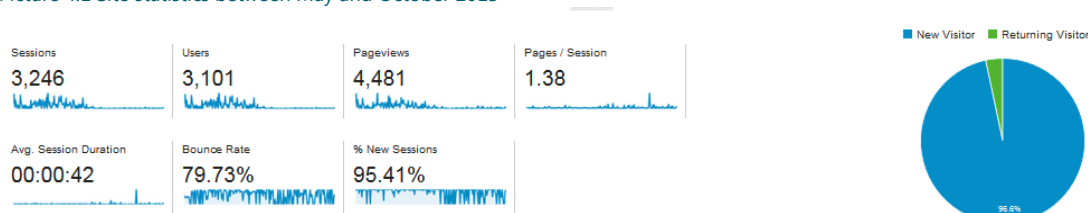
Remediation goals

Several parties in the Netherlands said the provisional limits of the RIVM as too strict from an international point of view. However the prevailing international standards are difficult to compare because they are based on risks from different perspectives (human, ecological, contact options, drinking water standard).

4.2 Statistics website

In May 2015 the website and questionnaire were launched. The website had over 3.200 visitors between May and October. Picture 4.1 present the site statics.

Picture 4.1 Site statistics between May and October 2015



Visitors from a wide range of countries visited the website. The top-10 countries are shown in picture 4.2. The number of submitted questionnaires and reactions on the website however, is disappointing. We received 12 questionnaires and some information was uploaded. The questionnaires are enclosed in appendix II.










There are a few different explanations for these results:

- We have chosen for one integrated (no tailor made) questionnaire for public stakeholders, private stakeholders and research institutes, while those groups are quite different.
- The emerging contaminant issue (and so the questionnaire) encompasses a broad range of aspects.
- The timing, right before the holidays, was not perfect. A number of key players were however interviewed after the holidays to improve the response.

In contrast to the limited response to the questionnaire, a lot of support and information on this topic was gained during the international meetings.

We received new information from scientists and gained knowledge through our own internet research. Based only on the response to the questionnaire, our conclusion was that the topic 'EC' is too complex for the transfer of knowledge by a website and/or questionnaire.

Picture 4.2 Number of visitors per country between May and October 2015

Country ?	Acquisition		Behavior			
	Sessions ? ↓	% New Sessions ?	New Users ?	Bounce Rate ?	Pages / Session ?	Avg. Session Duration ?
	1,611 % of Total: 49.63% (3,240)	96.96% Avg for View: 95.41% (1.62%)	1,562 % of Total: 50.44% (3,097)	90.32% Avg for View: 79.73% (13.26%)	1.36 Avg for View: 1.38 (-1.66%)	00:00:25 Avg for View: 00:00:42 (-41.79%)
1.  United States	717 (44.51%)	99.58%	714 (45.71%)	94.56%	1.18	00:00:12
2. (not set)	250 (15.52%)	100.00%	250 (16.01%)	99.20%	1.03	00:00:02
3.  Netherlands	73 (4.53%)	80.82%	59 (3.76%)	60.27%	3.08	00:02:34
4.  China	55 (3.41%)	100.00%	55 (3.52%)	100.00%	1.00	00:00:00
5.  Germany	54 (3.35%)	96.30%	52 (3.33%)	83.33%	1.65	00:00:28
6.  United Kingdom	49 (3.04%)	85.71%	42 (2.69%)	77.55%	1.45	00:00:30
7.  France	40 (2.48%)	90.00%	36 (2.30%)	80.00%	1.65	00:00:35
8.  Japan	38 (2.36%)	100.00%	38 (2.43%)	100.00%	1.00	00:00:00
9.  Australia	33 (2.05%)	78.79%	26 (1.66%)	69.70%	1.73	00:00:52
10.  Italy	27 (1.68%)	77.78%	21 (1.34%)	59.26%	2.78	00:02:14

4.3 Additional literature on EC

Besides the inventory of knowledge and awareness among the member of Common Forum and other EU member states and countries (USA, Australia, Norway), a literature assessment was conducted to available information about EC and PFOS/PFOA in these countries. The focus was on knowledge, research data and remediation techniques and this review also mapped out the European policy related to EC in soil, groundwater and sediment.

The results of this review are given in table 4.3. The reviewed documents were classified by subject (toxicity, awareness, policy/legislation, technical approach, and remediation) and a brief summary is given. All these documents are also available at the website www.emergingcontaminants.eu.

Table 4.3 Reviewed literature on EC and PFAS

Title document	Reference	Toxicity/fate	Awareness	Policy/legislation	Technical	Remediation	Synopses/short note
Study toxicity PFOS_3M_2000 [document isn't complete]	1	X					Not the entire document is available
EPA document concerns fade out PFOS by 3M	2	X					EPA review on toxicity study/Phase out PFOS by 3M
Presentation fire fighting foams_Ajax Chubb Varel_2013	3						Confidential
Dutch policy on Drinking water_Note 20140429-624133	4			X			Drinking water: paragraph 5.2. is about new pollutants
PFCs at FTF at Norwegian airports_presentation 2012	5		X				PFOS concentration at FTF at Norwegian airports
Analysetechnieken_Omegam_symp osium Expertisecentrum PFOS_23- 9-2013	6				X		Analytical methods PFOS in soil and groundwater
Bioaccumulation of PFOS in Freshwater Fish_Anchor QEA_2015	7	X					Presentation on toxicity in fresh water and fish
Presentation on analytical methods PFAS_CH2M_2015	8				X		Analytical methods measurements PFAS
PFOS exposure at contaminated sites & measures_CHEM15462	9	X					Toxicity: bioaccumulation PFOS
CLH Report Labeling and classification APFO_2010	10	X					Summary of characteristics APFO
CLH Report Labeling and classification PFOA_2010	11	X					Summary of characteristics PFOA
COT Statement PFOS_2014	12	X					COT statement on PFOS
Information on case study remediation PFOS-PFOA_CRC Care_ 2014	13					X	Australia: Information remediation with matCARE
Factsheet PFCs_CRC CARE	14		X				Australia: information about PFCs
Development of Guidance for CEC_TR32_CRC Care_2014	15			X	X	X	Australia: Technical report to develop methods and techniques
De (eco)toxiciteit van PFOS_RIVM_2013	16	X					Dutch presentation (RIVM) on eco-toxicity

Title document	Reference	Toxicity/fate	Awareness	Policy/legislation	Technical	Remediation	Synopses/short note
Definitieve Masterthesis Arno van Akkeren.docx	17	X	X				Master thesis about presence and toxicity
European Commission_PFOS Directive_122-2006	18			X			European regulation to phase out the use of PFOS
European Commission_POPs Waste regulation_756-2010	19			X			European regulation after decision Stockholm Convention
European Commission_POPs Restriction Concentrations_757-2010	20			X			European regulation with restrictions on POPs and PFOS
OECD report on EC arising from Agriculture_2012	21		X				Agriculture: presence and knowledge on EC in agriculture
ECHA_Opinion risk assessment APFO_2011	22	X					Risk assessment on APFO
ECHA Opinion risk assessment PFOA_2011	23	X					Risk assessment on PFOA
EPA_Factsheet on PFOS and PFOA_2014	24	X	X				US EPA: Factsheet PFOS and PFOA
European Union_WFD_EQS for priority substances_39-2013	25			X			EU: Water Framework Directive EQS for inland and marine water
European Commission_Risk Assessment PFOA and APFO_2010	26	X					RPS_Risk assessment on PFOA and APFO
EU Workshop_PFOA_1_agenda_2010	27	X					EU workshop on PFOA_agenda
EU Workshop_PFOA_2_Main conclusions	28	X					EU workshop on PFOA_summary
EU Workshop_PFOA_Affourtit	29	X	X				EU workshop on PFOA_risk assessment on use and presence
EU Workshop_PFOA_Bernauer	30	X					EU workshop on PFOA_DNEL derivation of PFOA
EU Workshop_PFOA_Buhrke	31	X					EU workshop on PFOA_toxical characterisation
EU Workshop_PFOA_Diderich	32		X				EU workshop on PFOA_OECD activities on PFOA (Agricultural)

Title document	Reference	Toxicity/fate	Awareness	Policy/legislation	Technical	Remediation	Synopses/short note
EU Workshop_PFOA_Dietz	33	X					EU workshop on PFOA toxicity and presence in Arctic marine
EU Workshop_PFOA_Michiels	34		X				EU workshop on PFOA Use in photo imaging industry
EU Workshop_PFOA_Posner	35		X		X		EU workshop on PFOA study on presence in daily products
EU Workshop_PFOA_Reineke	36	X	X				EU workshop on PFOA WWF presentation on risks
EU Workshop_PFOA_Schulte	37		X				EU workshop on PFOA Needs for policy and legislation in Germany
EU Workshop_PFOA_Vanwely	38	X					EU workshop on PFOA characteristics PFCs
European Commission_Implementatieplan Stockholm Conv - 2014	39		X	X			EU second EIP on POPs and Stockholm Convention_2014
European Union_Overview EU soil and land policy_2015	40		X				General presentation on EU soil and land policy
European Regulatory Activities on PFCs_2010	41			X			Presentation: ECHA and REACH related activities on PFCs in the EU
Environmental Fate and transport PFAS_CSoM_2015	42	X					Presentation on fate and transport studies in the USA
Ervaring met saneringstechnieken NL_2013-09-23 Expertisecentrum PFOS	43					X	Dutch summary: experience remediation techniques in the Netherlands
UWSF_Risikobewertung Perfluorotenside Hinblick REACH_Fricke Lahl_2005	44	X					REACH: summary of toxicity
Gezondheidsraad België_Humaan effect PFOS en PFOA	45	X					Belgium: Summary on human risks PFOS and PFOA
Australia Government_Regulations for leased airports in Australia	46			X	X		Australia: Outline Regulation for leased airports with PFC contaminations
Implementation of Restrictions on PFOS_EU stock inventory_ 2010	47		X				EU stock inventory on Cr-VI and PFOS_2010

Title document	Reference	Toxicity/fate	Awareness	Policy/legislation	Technical	Remediation	Synopses/short note
Stofgedrag PFOS en pilot saneringstechnieken_WUR_2013	48	X				X	Presentation: fate, behaviour and remediation pilot WUR
MONARPOP_Technical_Report_2008	49		X				MONARPOP report on awareness in POPs in Alp region EU
USA_Perdue University_research Abiotic treatment insitu remediation PFAS	50	(X)				X	Research on treatment in situ remediation PFAS
NL - RIKZ_Aquatic environmental assessment on PFAS_2002	51	X					Dutch study_UvA and RIKZ_PFAS in aquatic environment
NL - RIVM 607083001_Verkenning doelstelling herstel verontreiniging PFOS	52	X		(X)			Dutch study_RIVM_Values for contaminated land management
NL-RIVM_Guidance risk values PFOS in soil and groundwater	53	X		(X)			RIVM guidance risk values for PFOS in soil and groundwater
NL-RIVM 601714013_Environmental risk limits PFOS_water_2010	54	X					RIVM_study_PFOS: environmental risk limits in water
NL_TCB 2009 A054_Advies Nieuwe verontreinigingen in bodem	55	X		(X)			TCB_Advise on new pollutants in soil_Agricultural related
NORMAN_Factsheet Joint Program Activities_2015	56	X			X		NORMAN network: JPA 2015_little focus on groundwater
NORMAN_List of 970 substances_2015	57	X					NORMAN network: list with classification of 970 substances
NORMAN_Position paper_Passive Sampling and EC_2013	58				X		NORMAN network: passive sampling and EC
Paper_Releases from PFC production plant_Oliaei Kriens Weber Watson_2012	59	X					Paper about releases of PFOS and PFCs from PFC production plant
Presentation_Orbicon_PFAS in Denmark_2015	60		X	(X)			Presentation about PFAS in groundwater in Denmark
Webinar Presentation_Alcontrol Laboratory_Analyses PFAS 2013	63				X		Presentation_Analyses PFAS
PFA - presentation Analytical Methods-Reagen_date unknown	64				X		Presentation_Analyses PFAS

Title document	Reference	Toxicity/fate	Awareness	Policy/legislation	Technical	Remediation	Synopses/short note
Australia_Guidance PFAS_CRC Care	65			X			Australia: Presentation CRC Care_Development guideline on PFAS
European Chemical Bureau_meeting on PFOA in environment_2006	66	X					Summary record meeting on PFOA (2006)
UK HPA_Factsheet advise MAC PFOS in drinking water_2007	67			X			UK: drinking water_maximum acceptable concentration PFOS
UK HPA_Factsheet General information PFOS_2009	68	(X)	X				UK: toxicological overview PFOS
OECD_Hazard Assessment PFOS_2002	69	X					OECD_Assessment on risks and toxicology PFOS
USA_Presentation_Provisional health advisories PFOS and PFOA_2009	70	X					USA_presentation_Health and consumption of fish
European Union EA_Risk Evaluation Report PFOS_2004	71	X	(X)				EU Environmental agency_risk assessment on PFOS_2004
ECHA_Labeling and classification PFOS	72	X					Short document on labeling PFOS as a chemical substance
Dutch_PFOA in Aquatic milieu in the Netherlands_2013	73	X	(X)				Dutch_presentation about PFOS in aquatic environment
EU_POP_RC1-INF9-c_Study PFOS risks for Stockholm Convention_2004	74	X					Report_Nomination PFOS for list Stockholm Convention
European Commission_Study Waste related issues on new POP_2011	75	X	(X)		(X)		EU_Waste_Report on waste related issues on new POPs_2011
Nordic Council of Ministers_Norden_PFOA substances in Nordic countries_2013	76	(X)	X				Mapping presence (human and environment) of PFOA in Nordic region_2013
Presentation Roland Weber - POPEEC meeting 2011	77	(X)	(X)				Overview and awareness on POPs and its global presence_2011
NL_Removing PFOA from drinking water chain_Christian Eschauzier_2013	78					(X)	Presentation on research of remediation PFOA of the drinking water chain
Factsheet_SOLUTIONS EU project EC in sediments	79	(X)					Research program for EC in water

Title document	Reference	Toxicity/fate	Awareness	Policy/legislation	Technical	Remediation	Synopses/short note
Publication_How many POPs should we expect?_Scheringer_2012	80	(X)	(X)				Assessment and toxicology overview on POPs in our environment
Publication_Supporting Material_How many POPs should we expect?_Scheringer_2012	81	(X)					Supporting material overview on POPs in our environment
EU_Overview of search results EUR-Lex on POPs and EC	82			(X)			Quick scan on EU documents on POPs and EC
Swiss_Substance flow analysis for Switzerland PFOS and PFOA_2009	83	(X)	X				Switzerland: Report on PFOS and PFOA in Swiss_2009
UK-BGS_EC in groundwater_2011	84		X				UK: EC in groundwater_presence and risk assessment
Belgium: VITO_Factsheet PFOS, PFOA and derivatives_2009.pdf	85	X	X				Belgium: factsheet on substances PFOS and PFOA
Germany: Presentation Roland Weber_PFOS-PFAS in Germany_2010	86	(X)	(X)				Germany: presentation Case study contamination PFOS and PFOA
OECD_Report of a OECD workshop on PFAS_2007	87	X					OECD report of an OECD workshop on EC in 2006

4.4 Insight

The assessment on available literature shows the complexity of EC. There is very much research done on toxicity. Most of those studies were on awareness of EC in scope with fresh or marine water systems. For policy and legislation there are several documents from the EU commission. Last year some EU countries have done an inventory on the presence of PFOS//PFOA or PFAS substances near hotspots like landfills, waste water treatment installation, fire training areas and the carpet industry. The presence of PFOS and PFOA in the sediments of lakes and rivers needs further attention.

In several documents the conclusion is that it isn't clear which substances really need our attention or what must be done (and can be done) in terms of the management and remediation. This kind of conclusions or discussions can be seen as a hurdle to make the step or to take action.

DISCUSSION

In the introduction we already indicated that uncertainty and ambiguity related to the (financial) risks prevent an effective approach to EC. The questionnaire does not answer the question how the EC issues are addressed or should be addressed. Based on the questionnaire, the interviews and the literature assessment however we have identified how the observed deadlock can be broken. The main insights related to the approach for EC in soil, groundwater and sediments is that the sequence of the regular process (observation of a practical problem → research → policy → legislation/standards → technical development of analyses or treatment techniques → remediation → management) need to be adjusted. This is based on the input we have got from the questionnaire, interviews, literature and the discussions on several meetings in Europe.

Available knowledge and knowledge gaps

Policy makers faced with uncertainty ask for research which can eliminate or reduce these uncertainties. Because of these questions a lot of scientific studies on a large number of EC are carried out in recent years. Nevertheless the challenges of these substances are so diverse that those studies often do not provide the policymakers with the information they really need. The result is that there will be more questions which leads to more scientific research. Policy makers do not know where to start otherwise.

There are many uncertainties about EC. The first step to reduce these uncertainties is to subdivide the challenges to manageable tasks. This can be based on the current state of knowledge. The literature given in this study is a good first step to start with.

Prioritization

The uncomfortable feeling that one does not know where to start, influence the debate about EC. Some policymakers recognize the need for an approach on PFOS and PFOA. But at the same time the question arises why just these two substances need to be regulated and not the hundreds of other EC.

The list of POPs which was presented at the Stockholm Convention contains 30 (groups of) substances that are harmful to humans or the environment. The input for this list and the decisions that were made at the Stockholm Convention are based on a broad range of scientific research. Therefore the list is accepted by almost every United Nations member. Due to the ongoing research on the toxicity and fate of substances, it is certain that in the future new 'EC' will be added to this list. Also knowing that many POPs are EC and many EC are POPs. Rules and procedures for listing new contaminants are enclosed in the mandates of the Stockholm Convention. Monitoring these 'new' substances sounds like a huge task, but several of those substances already included in regular monitoring programs.

The NORMAN network¹ has developed a methodology² for prioritisation of EC.

¹ The NORMAN network is a permanent self-sustaining network (EU) of reference laboratories, research centres and related organisations for the monitoring and biomonitoring of emerging environmental substances. It enhances the exchange of information on emerging environmental substances, and encourages the validation and harmonisation of common measurement methods and monitoring tools so that the requirements of risk assessors and risk managers can be better met.

² http://www.norman-network.net/sites/default/files/norman_prioritisation_manual_15%20April2013_final_for_website.pdf

This prioritisation scheme represents a step forward on the road of EC, for which there is often a lack of data. The scheme can be used systematically in environmental risk assessments and in risk control programmes for monitoring the quality of soil, groundwater or sediments.

Based on the knowledge of scientific research and the conclusions of Stockholm Convention, parties (countries, municipalities, companies) are able to develop their own approach on EC, with respect to their own national/regional knowledge, policy and legislation.

The first step to an approach for EC is to find out which substances from the list of the Stockholm Convention are expected to emerge. This can be based on production and application, but it could also be based on monitoring data, like the data of the Water Framework Directive. Finally this approach will reduce the amount of potential substances that need to be verified in practice.

Legislation

The European legislation on EC is focused on the Water Framework Directive and REACH. Soil, groundwater and sediments are not structurally examined for EC, because there is a lack of specific legislation. Only when there is clear evidence for threats, an investigation of these substances is carried out per cache. Therefore it is unclear if EC in soil, groundwater and sediments, actually pose a threat.

Some European countries, for example Sweden, Denmark and Germany, are developing legislation and technical approaches for PFOS and PFOA in soil, groundwater or sediments at this moment or planning to do this in 2016-2017.

Suggestions for further steps

The main conclusion of the inventory we have carried out is that EU member states should work together to develop the best and effective approach for EC in soil, groundwater and sediments. Based on a joint strategy to share knowledge and expertise, it is most effective to work together on an international level, for example by the Common Forum members together with other stakeholders. This gives the advantage of commitment from all countries or stakeholders.

The most important step for this effective approach to EC in soil, groundwater and sediments, should be mapping of the problem in the practice. This mapping can be limited to the list of substances on the Stockholm Convention that are likely to be found in a (selection of) specific areas, because they are either used, discharged or produced in that areas. Based on available data it is known where the substances enter the environment and how these substances may spread (source-pathway approach). With this information the survey itself should be carried out in phases or at some pilot areas and maybe the mapping can be extrapolated to larger areas by using (geo)statistic tools.

The results of mapping and other the monitoring data gives an overview of the occurrence of EC in a region or country. Based on the data it will be possible to identify the actual risks to humans and the environment. Moreover, based on practical data, it is possible to analyse the transport mechanisms and the 'source-path-receptor' system. If there are risks it should be determined what can be done to prevent or eliminate them. If demonstrated that there are no risks, there will be no need to do more.

The main challenge at this stage will be to determine how to handle the possible risks. Therefore close cooperation between policy makers, scientists and engineers is necessary and more cooperation between European networks is needed.

In the future new EC will arise. Based on scientific research like the prioritisation of substances by the NORMAN network, the Stockholm Convention lists new substances every two years. An approach for soil, groundwater and sediments should take into account the experience and work of these institutes.

In summary the suggested next steps could be:

1. Identify international stakeholders and work out a program for the next steps together.
2. Selection of substances from the list of the Stockholm Convention which actually can pose risks in a specific region/country. This list by itself is not questioned.

3. Determine the regional hotspots of those substances, and determine what functions/areas may be threatened.
4. Establishment of a survey program for soil and groundwater. This research may be limited initially to a pilot field representative.
5. Based on the results:
 - Determine actual risks to humans and the environment. It is conceivable that at this point additional scientific research is desirable.
 - If risks occur in certain situations or areas, national or area-specific policy could be developed to eliminate those risks.
 - Challenge the market to develop knowledge and techniques - together with scientific institutes - so that the proposed policies are realistic and attainable.

INCLOSING REMARKS

In order to make issues with EC manageable, it should be clear where they may be encountered. Thereafter it should be determined whether the observed concentrations and standards actually cause risks. Finally the possible risks should be eliminated. Besides technical challenges, these issues also have several legal and organizational pitfalls.

An important issue is the legal status of contaminated sites. Some locations may be successfully remediated in the past for e.g. mineral oil but are still contaminated with substances we don't know at this moment. This kind of situation shows the need to review this topic and be clear about the situation, because as long as there is a potential claim for liability or costs no further actions will be taken by landowners.

In the Netherlands and Flanders a distinction is made between historical pollution and new pollution. The idea is that before 1975 (Netherlands) or 1995 (Flanders) people could not know that their actions could lead to soil contamination. Their liability (and their duties) for this kind of contamination is limited and clearly defined.

In case of EC it is not clear whether this is an old pollution or a new pollution. The harmfulness of these compounds was not known for a long time. Also some of these substances were necessary or permitted (for example PFOS in aqueous fire fighting foams). Who is responsible for these kinds of contamination? This uncertainty needs clearance.

The groundwater and soil system respond slowly. This means that any adverse effects will be noticed late. It also means that it takes a long time to notice the positive effects of remediation or control. During this time the taken actions may cause a high social impact and treatment will be very costly.

The debate about EC in soil, groundwater and sediments shows similarities with the climate debate. To protect our future soil and drinking water resources it is recommended to take steps in order to control these substances of spreading by soil, groundwater or sediments..

Appendices

I

APPENDIX: ARTICLE 'EMERGING POLLUTANTS IN THE ENVIRONMENT', MARIA GAVRILESCU, ET AL

See discussions, stats, and author profiles for this publication at: <http://www.researchgate.net/publication/259917427>

Emerging Pollutants in the Environment: Present and Future Challenges in Biomonitoring, Ecological Risks and Bioremediation.

ARTICLE *in* NEW BIOTECHNOLOGY · JANUARY 2014

Impact Factor: 2.11 · DOI: 10.1016/j.nbt.2014.01.001 · Source: PubMed

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Emerging pollutants in the environment: present and future challenges in biomonitoring, ecological risks and bioremediation

Maria Gavrilesu^{1,2}, Kateřina Demnerová³, Jens Aamand⁴,
Spyros Agathos⁵ and Fabio Fava⁶

¹“Gheorghe Asachi” Technical University of Iasi, Department of Environmental Engineering and Management, 73 Prof.dr.docent D. Mangeron Street, 700050 Iasi, Romania

²Academy of Romanian Scientists, 54 Splaiul Independentei, RO-050094 Bucharest, Romania

³Institute of Chemical Technology Prague, Department of Biochemistry and Microbiology, Technická 3, 166 28 Prague 6, Czech Republic

⁴Geological Survey of Denmark and Greenland (GEUS), Department of Geochemistry, Øster Voldgade 10, 1350 Copenhagen, Denmark

⁵Catholic University of Louvain, Faculty of Bioengineering, Agronomy and Environment, Earth and Life Institute, Place Croix du Sud 2, Box L7.05.19, B-1348 Louvain-la Neuve, Belgium

⁶Alma Mater Studiorum – University of Bologna, Department of Civil, Chemical, Environmental and Materials Engineering, Via Terracini 28, I-40131 Bologna, Italy

Emerging pollutants reach the environment from various anthropogenic sources and are distributed throughout environmental matrices. Although great advances have been made in the detection and analysis of trace pollutants during recent decades, due to the continued development and refinement of specific techniques, a wide array of undetected contaminants of emerging environmental concern need to be identified and quantified in various environmental components and biological tissues. These pollutants may be mobile and persistent in air, water, soil, sediments and ecological receptors even at low concentrations. Robust data on their fate and behaviour in the environment, as well as on threats to ecological and human health, are still lacking. Moreover, the ecotoxicological significance of some emerging micropollutants remains largely unknown, because satisfactory data to determine their risk often do not exist.

This paper discusses the fate, behaviour, (bio)monitoring, environmental and health risks associated with emerging chemical (pharmaceuticals, endocrine disruptors, hormones, toxins, among others) and biological (bacteria, viruses) micropollutants in soils, sediments, groundwater, industrial and municipal wastewaters, aquaculture effluents, and freshwater and marine ecosystems, and highlights new horizons for their (bio)removal. Our study aims to demonstrate the imperative need to boost research and innovation for new and cost-effective treatment technologies, in line with the uptake, mode of action and consequences of each emerging contaminant. We also address the topic of innovative tools for the evaluation of the effects of toxicity on human health and for the prediction of microbial availability and degradation in the environment. Additionally, we consider the development of (bio)sensors to perform environmental monitoring in real-time mode. This needs to address multiple species, along with a more effective exploitation of specialised microbes or enzymes capable of degrading endocrine disruptors and other micropollutants. In practical terms, the outcomes of these activities will build up the knowledge base and develop solutions to fill the significant innovation gap faced worldwide.

Corresponding author: Gavrilesu, M. (mgav@tuiasi.ro, mgav_ro@yahoo.com)

Introduction

Over recent decades, the world has experienced the adverse consequences of uncontrolled development of multiple human activities in, for example, industry, transport, agriculture, and urbanisation. The increase in living standards and higher consumer demand have amplified pollution of the air with, for example, CO₂ and other greenhouse gases, NO_x, SO₂ and particulate matter, of water with a variety of chemicals, nutrients, leachates, oil spills, among others, and of the soil due to the disposal of hazardous wastes, spreading of pesticides, sludge, as well as the use of disposable goods or non-biodegradable materials and the lack of proper facilities for waste [1]. Emerging pollutants (EPs) encompass a wide range of man-made chemicals (such as pesticides, cosmetics, personal and household care products, pharmaceuticals, among others), which are in use worldwide and which are indispensable for modern society [2]. It has been shown that between 1930 and 2000, global production of anthropogenic chemicals increased from 1 million to 400 millions tons per each year [3]. Statistics published by EUROSTAT in 2013 reveal that, between 2002 and 2011, over 50% of the total production of chemicals is represented by environmentally harmful compounds (Table 1). Over 70% of these are chemicals with significant environmental impact [4].

Furthermore, human activities have resulted in contamination of water resources with biological micropollutants, such as viruses and bacteria. Such agents have generated renewed awareness due to their potential pathogenicity and are referred to as emerging or reemerging pathogens. Biological micropollutants, such as enteric bacteria, mycoplasmas, viruses and protozoa, are the source of many waterborne diseases and remain a major cause of death worldwide [5]. A significant proportion of these diseases are caused by classical water related pathogens, but the spectrum of disease is constantly increasing. Diseases which were thought to be controlled may later reemerge, as exemplified by the appearance of *Cryptosporidium*, *Legionella*, rotavirus and hepatitis A virus in water [6].

The aim of this paper is to provide a focus on fostering a new challenge driven approach to R&D needs in the field of biomonitoring, evaluation of the ecological risks, and bioremediation of emerging chemical (pharmaceuticals, endocrine disruptors, hormones, toxins, among others) and biological (bacteria, viruses) micropollutants in soils, sediments, groundwater, industrial and municipal wastewaters, aquaculture effluents, and freshwater and marine ecosystems. It also identifies future challenges for reducing the environmental impacts from emerging micropollutants, with greater emphasis on innovative and advanced tools and technologies for monitoring, prevention and mitigation of environmental and health pressures and risks.

Emerging (micro)pollutants in the environment

Many chemical and microbial agents that were not traditionally considered contaminants can be found in various environmental

compartments and/or in areas where they were never used, mainly due to their persistence during long distance transport. The sources and pathways of these emerging contaminants can be increasingly associated with the waste and wastewaters resulting from industrial, agricultural or municipal activities [7]. Because of their particular characteristics, these pollutants require changes in the conventional approach to pollution prevention and control, although they result from similar domestic, commercial and industrial activities, as conventional contaminants [8]. Chemical micropollutants are often generated through degradation of organic compounds resulting in accumulation of persistent metabolites [9] or from the disposal of products such as pharmaceuticals in the natural environment. The increased appearance of biological pollutants during the production and distribution of drinking water may be related to several factors including changes in human demographic behaviour. Also, changes in agricultural practice towards intensive farming and spreading of manure or sludge on agricultural fields may cause leaching to surface and groundwater and health problems [10,11].

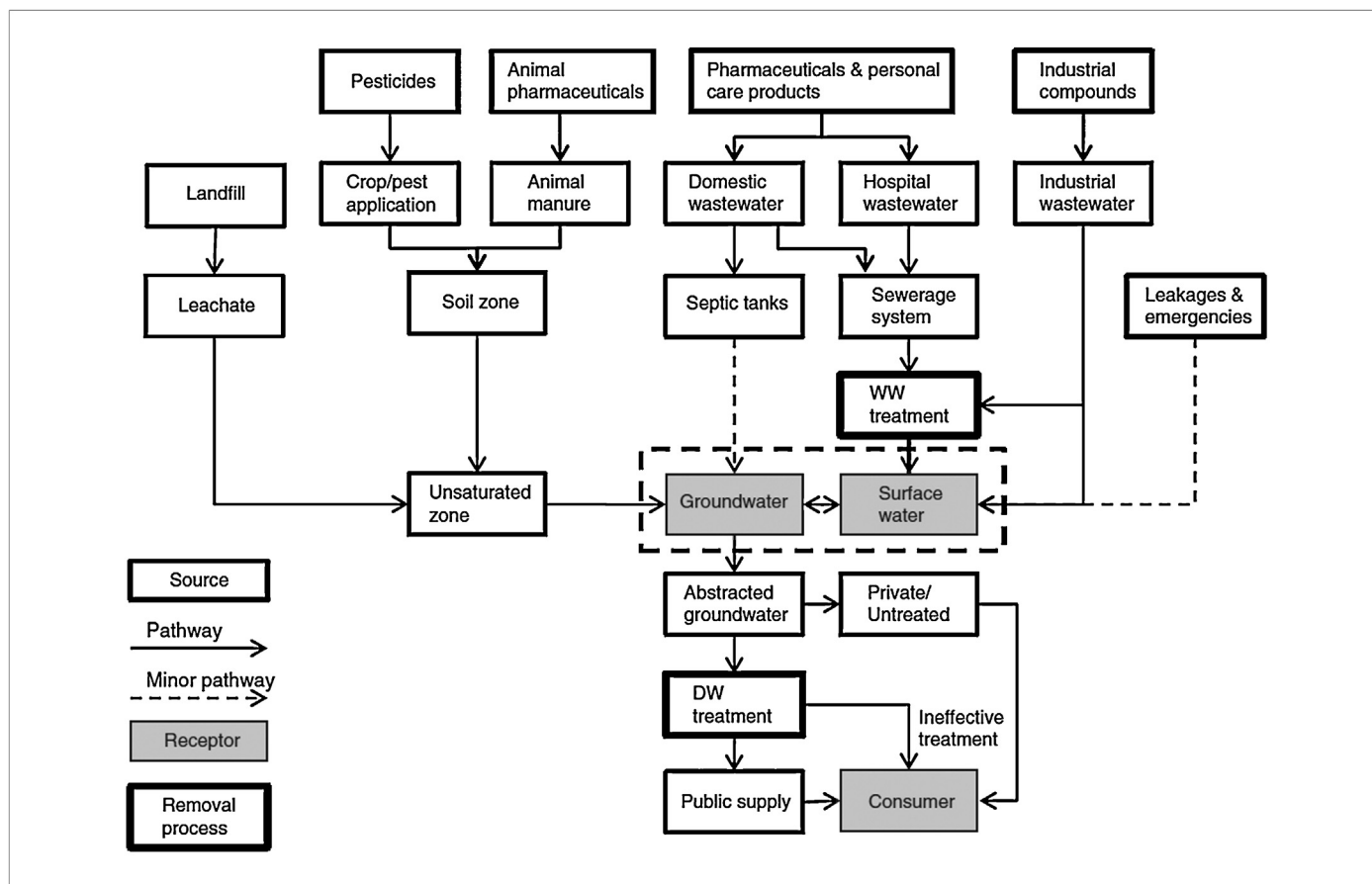
Pesticides continue to be detected in surface and groundwater, although some of them have gradually been banned and replaced by environmentally friendly substitutes [12,13]. Currently, research interest is directed toward pesticide metabolites, often detected in water sources and wastewater effluents at higher concentrations, being also biologically active and toxic [14,15]. Consequently, there is high interest in some categories of environmental contaminants, with particular chemical structures and properties, which interfere with endogenous hormone systems. These contaminants, denoted endocrine disruptors, are poorly inventoried and regulated and insufficient information exists regarding their occurrence, fate and impact in the environment. Also, because many have pharmaceutical, personal care and household uses (hormones, glucocorticoids, analgesics such as ibuprofen, estriol, additives in drugs and cosmetics such as siloxanes and parabens, and household cleansers), more information about their ecotoxicological effects is essential for their analysis and removal. Apart from the above endocrine disruptors, other products such as fire-retardants, heavy metals (cadmium, lead or mercury), widely used industrial chemicals (Bisphenol A) and some pesticides have been shown to impact natural endocrine systems [16–19].

Consequently, endocrine disruptors and their degradation intermediates constitute a topic of extensive research [16,17]. Pertinent studies indicate that toxicity data are not yet available for these compounds, which originate from various sources, among which the most relevant are direct releases into waters, wastewater treatment plants (WWTPs) (effluent and sludge), seepage from septic tanks, landfilling areas, and surface water run-off [20]. Pharmaceuticals, for example, are more concentrated in the wastewater discharged from hospitals, long-term care facilities and other medical facilities [21–23].

TABLE 1

Production of environmentally harmful chemicals, by environmental impact class in EU-27 (million tons) [4]

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total production of chemicals	330	333	349	351	355	362	338	292	339	347
Environmentally harmful chemicals, total	176	179	191	193	192	194	182	162	184	188
Chemicals with severe chronic environmental impacts	30	31	34	35	36	36	32	30	34	35

**FIGURE 1**

Schematic pathways of some emerging pollutants from sources to receptors [12].
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Although studies and reviews can be found in the literature on sources, occurrence, environmental behaviour and fate of emerging contaminants [12–14,24,25], the pathway of these pollutants from sources to receptors continues to be an essential subject for advanced research. This is because information is still poor, mainly due to the problems generated by the physico-chemical properties of target compounds, and the complexity of environmental characteristics, among others, which may determine an unexpected behaviour of the emerging pollutants in air, water, or soil [12,16,18,24]. To illustrate this situation, a schematic view of the routes by which some emerging pollutants enter various receptors (groundwater, surface water, consumers) was provided by Stuart *et al.* [12] (Fig. 1). Other studies have been carried out on the pathways of EP, in particular from humans and animals to environmental components [12,24,26,27].

Micropollutants in water and WWTPs

Overall, chemical and biological micropollutants are enriched in WWTPs [28], which should make these micropollutants easier to tackle and diminish the rate of their release into the environment. Literature surveys on the occurrence of various EPs in effluents from Sewage Treatment Plants (SPTs) or WWTPs reaching the natural surface waters have discussed an attenuation of their concentration in the natural receptors due to migration or retention by sorption, volatilisation, or dispersion, with transfer from

one environmental compartment to another [1,12,16,18,24,25]. Data on the occurrence and concentrations of some pharmaceuticals in effluents from STPs, WWTPs and surface waters, gathered from a literature survey [24] show that EP concentrations in effluents fluctuate widely (Table 2), most probably due to different doses applied in various regions and inconsistent efficiency of wastewater treatment.

Nevertheless information concerning the nature, variability, transport and fate of these compounds in wastewater and treatment facilities must be improved, because knowledge in this area is still limited. There are few studies devoted to monitoring and understanding the processes involved in conventional or innovative wastewater treatment in eliminating or reducing the concentrations of a large diversity of emerging pollutants at wastewater facilities [29,30].

Several studies on emerging contaminants have focused on surface waters because they are expected to contain significant concentrations from sources such as WWTP discharges, due to a variable potential removal of wastewater treatment for certain groups of EPs [12,14,15]. An interesting analysis has been elaborated by Deblonde *et al.* [25], describing concentrations found in wastewater influents and effluents (after treatment), focusing on phthalates, PCBs, PAHs, Bisphenol A and pharmaceuticals used for human health as well as disinfectants and hormones (Table 3).

TABLE 2

Data on the occurrence and concentration levels of various emerging pollutants in effluents from WWTP/STP and freshwater rivers, canals [24]Permission of Elsevier, License number 3278700294358, November 30, 2013.

Compounds	Range in concentration (ng/l)						Lowest PNEC (ng/l)	Percentage of parent compound excreted
	North America		Europe		Asia and Australia			
	Effluent, WWTP/STP	Freshwater-rivers, canals	Effluent, WWTP/STP	Freshwater-rivers, canals	Effluent, WWTP/STP	Freshwater-rivers, canals		
Antibiotics								
Trimethoprim	<0.5–7900	2–212	99–1264	0–78.2	58–321	4–150	1000	≥70
Ciprofloxacin	110–1100	–	40–3353	–	42–720	23–1300	20	≥70
Sulfamethoxazole	5–2800	7–211	91–794	<0.5–4	3.8–1400	1.7–2000	20,000	6–39
Analgesics and anti-inflammatory								
Naproxen	<1–5100	0–135.2	450–1840	<0.3–146	128–548	11–181	37,000	–
Ibuprofen	220–3600	0–34.0	134–7100	14–44	65–1758	28–360	5000	≤5
Ketoprofen	12–110	–	225–954	<0.5–14	–	<0.4–79.6	15.6 × 10 ⁶	–
Diclofenac	<0.5–177.1	11–82	460–3300	21–41	8.8–127	1.1–6.8	10,000	6–39
Salicylic acid	47.2–180	70–121	40–190	<0.3–302	9–2098	–	–	6–39
Mefenamic acid	–	–	1–554	<0.3–169	4.45–396	<0.1–65.1	–	–
Acetaminophen	–	24.7–65.2	59–220	12–777	1.8–19	4.1–73	9200	≤5
Antiepileptics								
Carbamazepine	111.2–187	2.7–113.7	130–290	9–157	152–226	25–34.7	25,000	≤5
Beta-blockers								
Propranolol	–	–	30–44	20	50	–	500	<0.5
Atenolol	879	–	1720	314	–	–	10 × 10 ⁶	50–90
Blood lipid regulators								
Clofibril acid	ND–33	3.2–26.7	27–120	1–14	154	22–248	12,000	–
Gemfibrozil	9–300	5.4–16	2–28,571	–	3.9–17	1.8–9.1	100,000	–
Bezafibrate	ND–260	–	233–340	16–363	–	–	100,000	40–69

ND—not detected; dashed line—not reported.

It is unlikely that the conventional treatment of wastewater or drinking water will be able to remove estrogens, androgens or detergent components due to the chemical structural stability of these compounds, as well as their low bioavailability, which affects biodegradation. In addition, municipal sewage sludge is also a repository for these emerging pollutants and only recently has there been an effort to assess their occurrence and biotreatment potential [31].

Bacteria and enteric viruses are abundant in sewage and the latter have also been detected in the effluents of WWTPs [32]. Because treated wastewater and untreated sewage may eventually drain into water resources, biological micropollutants threaten public health, and the development of new and cost-effective technologies for disinfection of water is therefore needed. It is also acknowledged that the treatment of these pollutant species requires the addition of advanced procedures, such as chemical degradation assisted by specialised microorganisms, or UV light action. Recently it was shown that biologically produced zerovalent silver nanoparticles (bio-Ag⁰) can be a very effective disinfectant which may be used at WWTPs, a technology which deserves further attention [33,34].

Micropollutants in freshwater resources

The consequences of micropollutants in aquatic ecosystems are of particular concern, because living organisms present here are subjected to exposure with potential consequences for future generations. The problem becomes more difficult when micropollutants are present in freshwaters (surface and groundwaters) at low (trace) concentrations (nanogram or microgram/L), depending on their source (Fig. 2) [14].

In this case, their detection and removal become difficult but important, because they put at risk the reuse of treated wastewater as well as the sustainability of water cycle management. Also, they are able to pose adverse risks for human health, associated with the development of pathogen resistance, endocrine disruption, and

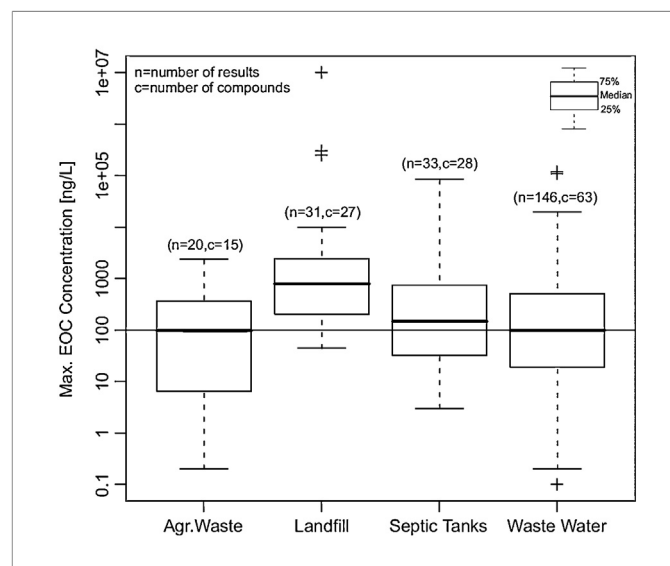


FIGURE 2

Maximum concentration of some emerging contaminants originating from major sources (agricultural waste, landfills, septic tanks, industrial and municipal wastewater) in groundwater (solid horizontal line is the EU drinking water limit for pesticides) [14].

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TABLE 3

Concentrations of some emerging pollutants ($\mu\text{g/L}$) in influent and effluent of wastewater treatment plants (WWTPs) [25] Permission of Elsevier, License number 3278701010264, November 30, 2013.

Pharmaceuticals compounds	Molecules	Influent						Effluent						Removal rate (%)
		Means	RSD	Median	Min	Max	n	Means	RSD	Median	Min	Max	n	
Antibiotics	Clarithromycin	0.344					2	0.15					2	56.4
	Ciprofloxacin	0.62	1.48	0.157	0.09	5.524	13	0.234	0.649	0.021	0.007	2.378	13	62.3
	Doxycyclin	0.65	0.94	0.098	0.067	2.48	10	0.420	0.426	0.227	0.038	1.09	9	35.4
	Erythromycin	0.58	0.242	0.56	0.346	0.83	3	0.297	0.237	0.2305	0.109	0.62	4	48.8
	Erythromycin-H ₂ O	2.025					2	0.59					2	70.9
	Methronidazole	0.09					1	0.055					1	38.9
	Norfloxacin	0.115	0.056	0.0905	0.066	0.25	12	0.0526	0.0985	0.0195	0.007	0.33	10	54.3
	Ofloxacin	0.482	0.884	0.156	0.007	2.275	6	0.171	0.317	0.0485	0.007	0.816	6	64.5
	Roxithromycin	0.78	0.737	0.81	0.0272	1.5	3	0.472	0.435	0.54	0.008	0.87	3	39.5
	Sulfamethoxazole	0.32	0.248	0.2905	0.02	0.674	10	0.264	0.150	0.243	0.07	0.62	11	17.5
	Sulfapyridin	0.492					1	0.081					1	83.5
	Tetracyclin	48					1	2.375					2	95.1
Antiepileptics	Trimethoprim	0.43	0.401	0.251	0.0535	1.3	15	0.424	0.363	0.32	0.04	1.34	17	1.4
	Carbamazepine	0.732	0.869	0.25	0.0819	1.68	6	0.774	0.789	0.37	0.042	2.1	13	−5.7
	4-Aminoantipyrine	1.517					1	0.676					1	55.4
	Antipyrin	0.04					1	0.027					1	32.5
	Codein	2.8605					2	1.93					2	32.5
Analgesics and anti-inflammatories	Diclofenac	1.039	1.283	0.232	0.16	3.1	6	0.679	0.701	0.55	0.04	2.448	11	34.6
	Ibuprofen	13.482	25.639	3.495	0.0143	22.7	10	3.480	1.489	0.56	0.03	12.6	17	74.2
	Indomethacine	0.136												
	Ketoprofen	0.483	0.286	0.441	0.146	0.94	5	0.333	0.148	0.34	0.125	0.63	9	31.1
	Ketorolac	0.407	0.407				1	0.228					1	44.0
	Naproxen	5.077	8.251	2.363	0.206	23.21	7	0.934	0.873	0.452	0.017	2.62	13	81.6
Lipid regulators	Clofibrac acid	0.215	0.251	0.12	0.026	0.5	3	0.131	0.136	0.12	0.012	0.36	5	39.1
	Fenofibrac acid	0.079					1	0.196	0.161	0.13	0.078	0.38	3	−148.1
	Bezafibrate	1.948	2.320	1.4205	0.05	4.9	4	0.763	0.963	0.13	0.035	2.2	5	60.8
	Gemfibrozil	1.562	1.704	0.71	0.453	3.525	3	0.757	1.068	0.323	0.0112	2.86	6	51.5
	Acebutolol	0.335												
Betablockers	Atenolol	1.080	0.946	0.996	0.03	1.197	4	0.468	0.381	0.345	0.16	1.025	4	56.7
	Celiprolol	0.44					1	0.28					1	36.4
	Metoprolol	1.535	2.290	0.61	0.02	4.9	4	0.679	0.657	0.73	0.019	1.7	5	55.8
	Propanolol	0.198	0.269	0.005	0.036	0.51	3	0.102	0.0712	0.093	0.03	0.18	5	48.5
Diuretics	Sotalol	1.667					2	0.79					2	52.6
	Furosemide	0.413					1	0.166					1	59.8
	Hydrochlorothiazide	2.514					1	1.176					1	53.2
	Amidotrizoic acid	2.5					1	2.494					1	0.2
	Diatrizoate	3.3					1	3.3					1	0.0
Contrast media	Iotalamic acid	1.8					1	1.820					1	−1.1
	Iopromide	9.205					2	2.014	1.40	2.63	0.411	3	3	78.1
	Iomeprol	6.05					2	1.606					2	73.5
	Iohexol	6.7					2	2.706					2	59.6
Cosmetics	Iopamidol	2.3					1	1.9					1	17.4
	Galaxolide	4.281	5.01	2.031	0.79	10.02	3	1.019	0.243	1.08	0.751	1.225	3	76.2
Psycho-stimulants	Tonalide	0.878					2	0.21					2	76.1
	Caffeine	56.634	52.769	52.424	3.69	118	4	1.771	3.620	0.64	0.174	12	10	96.9
Desinfectant	Paraxanthin	26.722					1	0.836					1	96.9
	Triclosan	0.852	0.659	0.317	0.3	1.93	8	0.198	0.161	0.18	0.012	0.219	6	76.8
Antidepressants	Fluoxetin	5.85					1	0.112					2	98.1
Plasticisers	Molecules													
	DEP	19.64	19.64	14.8	0.19	50.7	5	0.68	1.11	0.02	0.0002	2.58	5	96.5
	DBP	12.44	17.59	5.27	0.15	46.8	6	0.52	1.04	0.34	0.0005	2.38	5	95.8
	BBP	9.17	16.1	3	0.01	37.87	5	0.7	1.36	0.076	0.0003	3.13	5	92.4
Phthalates	DEHP	39.68	44.81	23.6	0.13	122	7	3.87	4.91	2.75	0.0016	14.2	8	90.2
	DMP	1.51	1.39	1.24	0.26	3.32	4	0.038	0.066	0.00019	0.00006	0.115	3	97.5
	DIBP	5.98	9.75	1.7	0.04	20.48	4	5.24					2	12.4
	Bisphenol A	2.07	3.1	0.563	0.088	11.8	14	0.6	1.09	0.05	0.006	4.09	15	71.0

DEP: diethyl phthalate; DBP: di-*n*-butyl phthalate; BBP: *n*-butyl benzyl phthalate; DEHP: bis(2-ethylhexyl) phthalate; DMP: dimethyl phthalate; DIBP: diisobutyl phthalate.

TABLE 4

Emerging contaminants detected in European groundwaters and surface waters as originating from wastewater treatment or other point sources [12] Permission of Elsevier, License Number 3278710639716, November 30, 2013.

Site	Source	Compounds detected
UK surface water		
England and Wales	Contaminated and control sites	Polychlorinated dibenzo- <i>p</i> -dioxins and dibenzofurans detected in all sediments sampled
Thames in south west London and rural river	WTW	Ibuprofen, paracetamol and salbutamol quantified in all samples. Mefenamic acid (NSAID) in 70% of samples. Propanolol (β -blocker) < LOD
Tyne Estuary	WTW	Clotrimazole, dextropropoxyphene, erythromycin, ibuprofen, propanalol, tamoxifen, trimethoprim quantified Clofibrac acid, diclofenac, mefenamic acid, paracetamol < LOD
Tees, Mersey, Aire river and estuary	Industry-WTW	APEs detected above threshold
Taff&Ely, South Wales	WTW	Trimethoprim, erythromycin, amoxicillin, paracetamol, tramadol, codeine, naproxen, ibuprofen, diclofenac, carbamazepine, gahapentin most frequently detected 41 others detected including illicit drugs
Inland streams	WTW	Ibuprofen, mefamic acid, diclofenac, propanalol, dextropropoxyphene, erythromycin, trimethoprim, acetyl-sulfamethoxazole, detected Paracetamol, lofepramine not detected
Ouse, West Sussex	WTW	Bisphenol A, oestrone, 17 β -oestrodial consistently detected, Propanalol, sulfamethoxazole, carbamazepine, indomethacine, diclofenac variably detected Mebeverine, thioridazine, tamoxifen, meclofenamic acid
UK		Diuron
Stream, Tunbridge Wells	Storm event, fruit growing	Simazine, diuron, NP, endosulfan sulphate, pendimethalin
Thames, 1988–1997		Atrazine, simazine, lindane
European groundwater		
Eastern England	STW	Pharmaceuticals [<20 –max]: ibuprofen (5044), erythromycin (1022), dextropropoxyphene (082), diclofenac (568), mefenamic acid (366), propanolol (215), acetyl-sulfamethoxazole (239), trimethoprim (42)
Berlin, Germany	STW	Pharmaceuticals: clofibrac acid (7300), clofibrac acid derivative (2900), propyphenazone (1465), Phenazone (1250), salicylic acid (1225), primidone (690), gentisic acid (540), <i>N</i> -methylphenacetin (470), diclofenac (380), gemfibrozil (340), ibuprofen (200), fenofibrate (45), ketoprofen (30)
Leipzig, Germany	STW	Bisphenol A (7000), NP (1000), caffeine (–140), carbamazepine (90), tonalide (–6), galoxalide (–2.8)
Halle, Germany	STW	Bisphenol A (–1 to 1136), carbamazepine (–2 to 83), galaxolide (3–19)
Baden-Württemberg, Germany	STW	Maximum concentrations: amidotrizoic acid (1100), carbamazepine (900), diclofenac (590), Sotalol (560), sulfamethoxazole (410), iopamidol (300), anhydro-erythromycin (49), phenazone (25)
France	Regional survey	Hormones (0.4–4): levonorgestrel (4), progesterone (1.6), testosterone (1.4); Pharmaceuticals (0–14): oxazepam (14), carbamazepine (10.4), acetaminophen (10.3), metformin (9.9), diclofenac (9.7), salicylic acid (metabolite) (6.5), atenolol (5.5), sulfamethoxazole (3)

APEs: alkyl phenol ethoxylates; LOD: limit of detection; NSAID: non-steroidal anti-inflammatory drug; STW: Sewage Treatment Work; WTW: wastewater treatment work.

chronic toxicity [35]. The uptake, mode of action, and biological endpoints of each emerging contaminant must be researched and documented to establish a correlation between contaminant and consequence.

A successful approach to the problem of emerging contaminants should be highly interdisciplinary [36]. Drinking water resources such as groundwater are often contaminated by extremely low concentrations of pesticides in the nanogram to microgram/L range, but still above the EU limit values. Surveys of groundwater contaminants detected in several European areas show that most of these EPs can be associated with the impact of WWTP or other point sources (Table 4), more significantly than recognised hitherto [12,37,38].

Moreover, European monitoring programmes discriminate among the most frequently detected EP in groundwater (Fig. 3) [12]. The risk to groundwater posed by the presence of these EPs, and consequently to drinking water, is clear. Development of new technologies for treatment of drinking water resources to below the EU threshold limit is urgent.

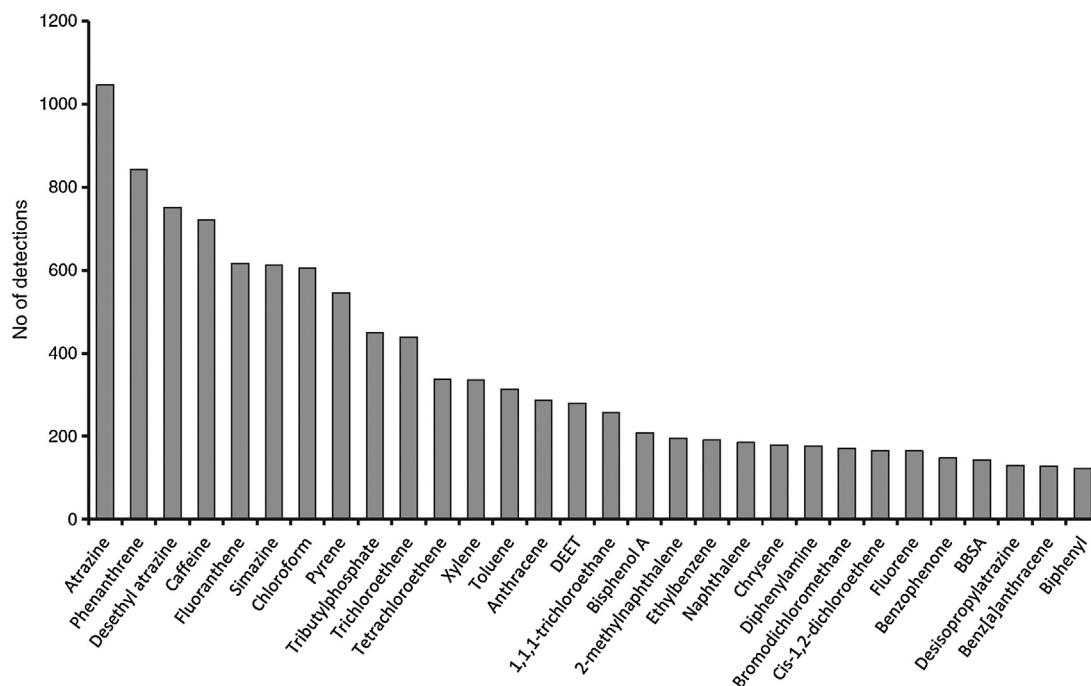
(Bio)monitoring and ecological risk assessment for emerging pollutants

R&D for impact and risk assessment

The relevance of emerging and new chemical and biological agents and their impact on soil, water and ecosystems can be addressed by the following research challenges:

- identification and preparation of comprehensive lists of emerging contaminants;
- characterisation of interactions and physical/chemical fate of such chemicals/biological emerging pollutants in soil, sediment and water ecosystems;
- assessment of the functioning of the water/soil system in the presence of emerging pollutants.

Establishing action plans for emerging and reemerging infectious agents is an additional need worldwide. There is little toxicological information for the majority of the chemicals in use, predominantly with regard to long-term, low-level exposure. Current challenges which the environment is facing are often hidden so that long-term threats or intermittent exposure can restructure

**FIGURE 3**

The most frequently detected compounds in European groundwater included in the Environmental Agency database (DEET = *N,N*-dimethyl-toluamide; BASA = *N*-buthylbenzene sulphonamide; BBSA = *N*-buthylbenzene sulphonamide) [12]. With permission of the publishers.

ecosystems and often lead to a decrease in biodiversity and a loss of important functions and services [39,40]. In this context, a major problem lies in the identification of future hazardous or potentially dangerous chemicals and biological agents hazardous or potential dangerous. An inventory of the available information in terms of persistence, fluxes, toxicity, endocrine disruption potential of both individual compounds and complex mixtures is lacking.

Although the literature on the fate of these substances appears to be extensive, data about their environmental effects at the realistic low concentrations at which they exist in different media are limited, especially when exposure to these compounds could occur. Hence, the development of new technologies for remediation and disinfection of water resources to drinking water standards is an ongoing challenge. In several cases, regulations to impose long-term impact assessment of the exposure to low levels of chemical compounds in the environment are missing, because important classes of these compounds have not yet been studied in detail. This has been mainly attributable to the lack of appropriate standards for instrumental analysis techniques in the case of low concentrations of micropollutants in environmental components [1,16]. To understand the full range of potential contaminant effects, it is important to measure and monitor pollutant concentrations at the emission source, within the environmental compartments as well as in living organisms (invertebrates, fish, among others) [41,42]. Currently, some groups of physico-chemical treatment methods could be applied, coupled with toxicity tests after each stage of treatment, to remove one or more classes of

toxic compounds, despite the time and necessary costs for these tests.

Online monitoring would have the advantage that it can improve the reliability of monitoring data, but involves expensive equipment and relative high maintenance costs [43,44]. An efficient option now being applied refers to passive sampling methods, such as Polar Organic Chemical Integrative Samplers (POCIS), which can sample water over a long period, providing time weighted average (TWA) concentrations [45,46].

Understanding the causes of ecosystem harm or effects resulting from chronic exposure to a pollutant is not an easy task and one which requires innovative approaches. Also, there is a growing agreement that chemical data alone are not sufficient to assess the potential risks of all emerging pollutants, and those analyses of pollution-induced biological and biochemical effects are desirable to evaluate the impact of chemical pollutants on human health.

Biomonitoring and biosensors

Biomonitoring tools (e.g. bioassays, biomarkers, microbial community analyses) have great potential for increasing confidence in the risk assessment of both regulated and emerging chemical pollutants. Sensors developed to determine several analytes in parallel are useful tools in environmental monitoring and screening.

The comprehensive term 'biosensor' denotes a system capable of detecting the presence of a substrate by using biological components, which then provides a quantifiable signal [47]. Recently, there has been an expansion of studies and research on biosensing

techniques and devices for environmental monitoring and similarly for genetic engineering and sensor cell development. For example, it is assumed that many endocrine disruptors can bind to the oestrogen receptor (ER) as agonists or antagonists. Therefore, the chemical binding capacity of ER would be a factor in screening or testing the potential toxicity of these substances on the environment and biosensors for endocrine disruptors have been developed, taking advantage of this property [48,49]. Moreover, molecular self-assembly, inspired by nature, has been proposed to synthesise nanostructures with distinctive functions, because current detection methods for pathogenic bacteria, protozoa, viruses, or helminths proved to be sometimes inaccurate, but also costly in terms of resources and time [50]. The self-assembly technique makes possible organised, patterned nanostructures which can involve biomaterials (proteins, lipids, nucleic acids), without external control and directions, which can then be applied to the development of amperometric immunosensors [51,52].

Because monitoring of multiple species would be recommended in a real-time parallel procedure, the current tendency is to develop large-scale biosensor clusters, especially if highly miniaturised signal transduction elements are necessary. Genomics is a new tool in recognising and understanding the molecular pathways disturbed by emerging pollutants, and is able to relate them to both the whole organism and population level effects. Technologies such as DNA microarrays are successfully applied in ecotoxicogenomics, an emerging field in ecotoxicology, to understand the effects of pollutants at the molecular level [53]. Furthermore, the bioavailability of nanoparticles in environmental compartments can be investigated by developing molecular biomarkers as detection tools for emerging contaminants. This is essential for risk assessment and decision making for remediation of contaminated soils and sediments. Measuring the concentration levels of polluting compounds through techniques which

allow the determination of contamination bioaccessibility as well as the prediction of microbial degradation and availability in the environment is a crucial part of environmental (bio)monitoring [54].

Quantifying the bioavailability of organic contaminants in soil and sediment is crucial for risk assessment and decision making for contaminated land remediation. It would therefore be highly opportune to develop techniques that can directly predict microbial bioavailability and the environmental degradation potential of these contaminants.

Innovative approaches in bioremediation of emerging pollutants

Environmental hazards and risks that occur as a result of accumulated toxic chemicals or biological micropollutants could be reduced or eliminated through the application of various (bio)-technologies [1]. These could take the form of treatment/remediation of historic pollution, disinfection of water resources addressing chemical and biological agents resulting from changed human demographic behaviour, breakdown of public health measures and current industrial/agricultural practices through pollution prevention and control [55,56].

Thanks to biotechnological solutions some of these pollutants can be readily degraded or removed. Studies have demonstrated that these solutions involve the action of microbes, plants and animals under specific conditions that address both abiotic and biotic factors, so as to achieve contaminant mineralisation, transformation or immobilisation [1,57–59]. For example, the combination of biological processes with adsorption on solids in the treatment of wastewaters can provide 45–99% removal efficiency of EDCs (Endocrine Disrupting Chemicals) from influent [16].

Monitoring and managing the biological aspects of bioremediation require the characterisation of the fate and behaviour of the compounds of interest in the environment to update the choice of

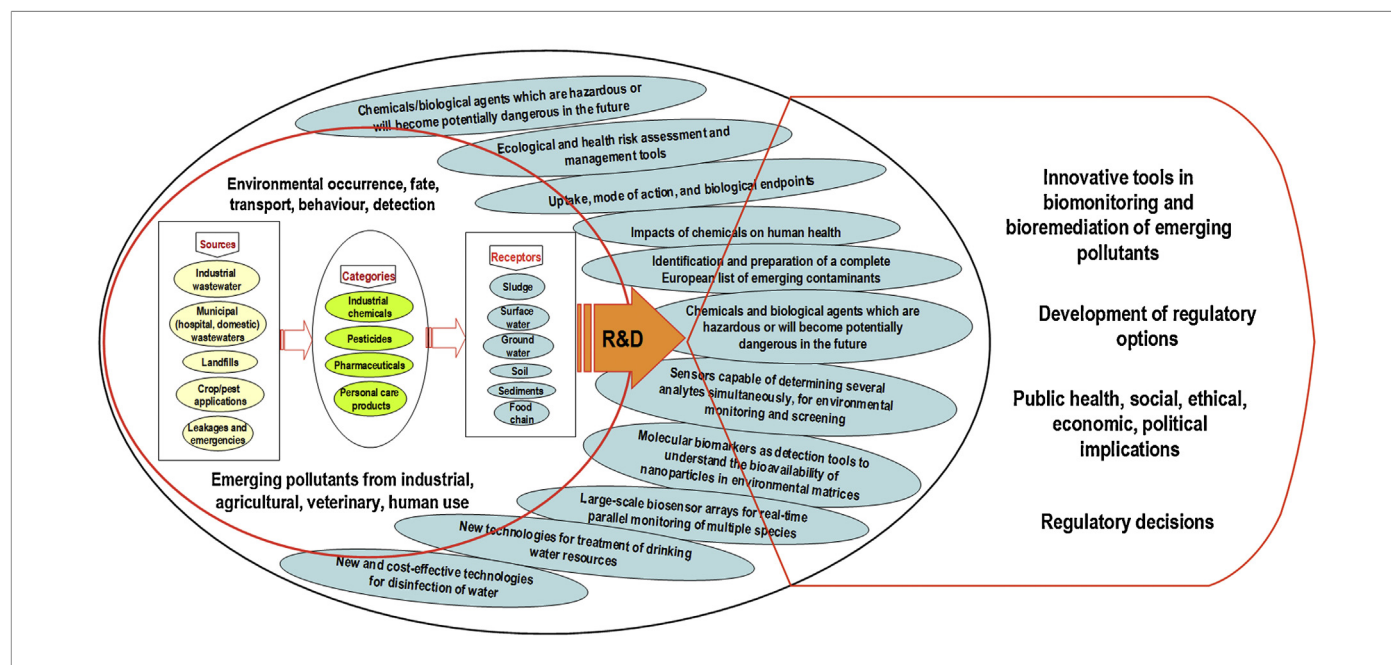


FIGURE 4

R&D needs for emerging pollutants in the environment considering sources, biomonitoring, ecological risks and bioremediation.

bioremediation strategy. However, at present it is difficult to suppose that the environmental impacts of trace chemicals would be minimised or removed, mostly as a consequence of insufficient information being available. This highlights the importance of a consistent link between R&D needs for the assessment and treatment of emerging pollutants and the tools, equipment and know-how which contributes to the fulfilment of these needs. Such an integrated approach should take into consideration the entire lifecycle of the pollutants, from the source of emission to their removal through treatment and remediation techniques, without neglecting the impacts and risks they may pose to the environment and human health (Fig. 4).

Pollution control in the aquatic environment can be achieved by applying the well-established activated sludge wastewater treatment. However, biological processes carried out in conventional treatment systems (activated sludge) showed a low efficiency in removing EDCs from wastewater, even in WWTP units with multiple biological treatment units [57].

Membrane bioreactors (MBRs) are regarded as feasible options in relation to conventional treatment plants, because they have proved to be efficient in removing recalcitrant compounds that cannot be eliminated or biodegraded in activated sludge systems. Some studies have shown that the elimination of EDCs in MBRs before disinfection may result in removal effectiveness of 96% for cholesterol, stigmastanol and coprostanol in municipal wastewater, compared to 85% efficiencies obtained in a conventional treatment plant, with influents of similar loadings. However, if the sludge retention time (SRT) is extended, MBR performance for the removal of several compounds may diminish [16,60].

Isolation of activated sludge bacteria capable of degrading endocrine disruptors can provide great opportunities to effectively remove these compounds, which are sometimes difficult to degrade even by advanced treatment processes such as hydrolysis or photocatalysis. White rot fungi and their oxidative enzymes are also attractive candidates to decontaminate waters containing EDCs, such as the ubiquitous plasticiser Bisphenol A [61,62]. The development of innovative/advanced packed or fluidised bed bioreactors or MBRs is also necessary for a more effective exploitation of such specialised microbes or enzymes.

The growing outbreaks of infectious waterborne diseases are a challenge to both the water and public health sector. The development of new (bio) technologies for water disinfection and monitoring biological micropollutants is therefore urgent. Novel concepts for the removal of such agents and of potential usefulness for the biotreatment of water and wastewater are starting to emerge [63,64]. The recently demonstrated co-metabolism of estrogenic compounds during nitrification (including the action of ammonia oxidising Archaea) might also be applicable to the

removal of other micropollutants such as pharmaceuticals and personal care products (PPCPs), while recruitment of other heterotrophic bacteria seems to be necessary to further degrade the intermediate metabolites of these micropollutants produced by the action of aerobic nitrifiers [63,65].

Scientifically validated and innovative processes and tools are further necessary to tackle these matters and the public and decision makers' needs in terms of chemicals and pathogens impacts on environment and human health.

Concluding remarks

Ensuring the elimination of emerging contaminants of environmental concern requires future studies and research to develop robust (bio)remediation processes elaborated on a sustainable basis. Our analysis shows that emerging contaminants continue to cause new and serious challenges to water, air, soil, natural resources, ecosystems and human health. It is also evident that the production of new chemicals extends and often goes beyond the power of current safety monitoring and risk assessment methods, as well as of existing preventative and remediation technologies.

Some issues should be addressed so as to generate a synergistic effect between the environmental influence on fate and (bio)availability of chemical (organic and inorganic) contaminants and the selection and performance of the most appropriate bioremediation processes, as well as of complementary techniques that support the effective operation and monitoring of a bioremediation approach. Considering the current situation and based on our study, it is clear that several interconnected factors must be taken into account: contaminant concentration; contaminant/contamination characteristics and category; scale and level of contamination; the risk intensity generated for health or the environment; the opportunity to be applied *in situ* or *ex situ*; the later use of the site; and available resources. Moreover, the removal of pollutants from any given environment would be made more predictable by applying multidisciplinary techniques. The results of R&D efforts will lead to future regulations, entailing their occurrence, bioremediation targets and their potential environmental and health risks.

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II

APPENDIX: FILLED IN QUESTIONNAIRES (WITH PERMISSION TO PUBLISH)

Questionnaire on Contaminated Land Management in Europe

Emerging contaminants

AIM OF THIS QUESTIONNAIRE

With increasing frequency countries and organisations are faced with chemicals that have not been considered as 'contaminants' before. Some of these chemicals could be a potential risk to humans and/or the environment. These are the so-called 'emerging contaminants'. Roughly defined by the United States Geological Survey as "any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects".

Characteristic for emerging contaminants is that too little is known about the occurrence, the actual risks and the approach to formulate appropriate policy and legislation. To properly identify how to deal with emerging contaminants knowledge, awareness and understanding is necessary.

Commissioned by the Ministry of I&M / RWS (Netherlands) and the OVAM (Flanders), this questionnaire has been developed. This questionnaire aims to wrap up available knowledge and experience related to legislation, governance and policy. The focus is on the presence and the curative policy on emerging contaminants that are already present in the soil, groundwater and sediments.

This questionnaire is a first step to decide whether it is necessary to develop an effective approach on how to deal with emerging contaminants. The results of this inventory will be shared and discussed. Based on this discussion a decision is made whether the development of a strategy on how to deal with emerging contaminants is necessary.

APPROACH

The group of emerging contaminants is very diverse in terms of toxicity, behaviour, remediation/treatment technique and so forth. As a consequence, the dimensions of the problem are not clear. Also the current knowledge and especially the actual approaches on how to deal with emerging contaminants in different countries are not well known.



DDT DDE DDD



NANO PARTICLES

10⁻⁹

Characteristics of emerging contaminants

The various emerging contaminants have in common that there is much uncertainty about them, which leads to the absence of a strategy and policy. The following observations about emerging contaminants are:

- More than 2100 scientific studies have shown that they pose a potential risk to humans, plants and / or animals. However, there's a lack of knowledge of the practical implications;
- The emerging contaminants are not examined in regular environmental investigation. This leads to a lack of data;
- As a result of a lack of data, little is known about the practical situation and risks in the soil, sediment and groundwater system;
- Appropriate strategies and technologies to control existing contaminants are not in development;
- Uncertainty about legal and financial consequences of (potential) contamination will hamper an efficient approach.

This questionnaire aims at the policy and legislation in the European Union, related to man-made emerging contaminants that already are present in the environment in the compartments soil, groundwater and sediment. It is not about preventive legislation (REACH), nor about the application of emerging contaminants.

Therefore we distinguish the following themes in the questionnaire:

- Awareness of emerging contaminants (questions 1 - 5);
- Policy and legislation related to emerging contaminants (questions 6 - 8);
- Technical approach (questions 9 - 13);
- Focus on PFOS and PFOA as a 'pilot' emerging contaminants (questions 14 - 17);
- Suggestions for follow-up (questions 18 - 21).

PROCESS AND RESULTS

The questionnaire is spread among the members of the Common Forum and. Also members of the related network organisations SedNet and NICOLE, which are also participating in the Common Forum, are asked to fill in this questionnaire.

For this inventory we developed a website (www.emergingcontaminants.eu) and this questionnaire. The website can be used to upload relevant documents that may be used and shared publicly.

Please feel free to send the web-link or this form to colleagues or related organisations if you think that they can give valuable information. It is also possible that not all questions can be answered. Please skip those questions or contact a colleague for those questions! The form can be saved and edited or filled later on.

Participants will be informed about the results of the questionnaire. Results of this questionnaire will be treated anonymously. Information such as name, function and organisation is not necessary, but might be helpful for us to interpret the results.

It is possible that you cannot answer all questions. Please skip those questions and continue the questionnaire. You can also send this form to a colleague. The form can be saved and edited or filled later on.

0. Fill in your country and function:

Country

Organisation:

Function

Expertise

Optional:

Telephone no.

Email

Unless you tick the next boxes, answers will be treated strictly anonymously.

- ☐ I have no objection that my answers will be related in a report to me.
- ☐ I have no objection that my answers will be related in a report to my organization.
- ☐ I have no objection when the documents I upload will be related in a report to me or my organization.
- ☐ I have no objection when the documents I upload will be accessible to other people via a website.

Documents, links or other information, which may be useful in this survey, can be sent to the following e-mail address:

Info@emergingcontaminants.eu

Also questions regarding this questionnaire can be sent to info@emergingcontaminants.eu. You can also contact us at phone number +31 570-665878 (Arne Alphenaar, TTE) or +31 570-697184 (Martijn van Houten, Witteveen+Bos).



AWARENESS

Definition by the United States Geological Survey:

“Any synthetic or naturally occurring chemical that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and(or) human health effects”.

1. Do you endorse the given definition of ‘emerging contaminants’?

- ☐ Yes, continue with question 2
- ☐ No, please give a better definition or comment on this definition:

The number of emerging contaminants is extensive. Therefore we further focus on one special group of emerging contaminants, the Persistent Organic Pollutants (POP). A number of Persistent Organic Pollutants are included in The Stockholm Convention on Persistent Organic Pollutants.

Stockholm Convention

This is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. In the Stockholm Convention chemicals targeted by the Convention are listed.

2. Please indicate which POP's from the Stockholm Convention you are familiar with in terms of contaminated land management/river basin management (soil, groundwater, sediments):

- ☐ Aldrin
- ☐ Bromo diphenylethers
- ☐ Chlordane
- ☐ Chlordecone
- ☐ HCB (Hexabromocyclohexane)
- ☐ Dicofo
- ☐ Dieldrin
- ☐ Endrin
- ☐ Heptachlor
- ☐ Hexabromobiphenyl
- ☐ Hexabromodiphenyl ether and heptabromodiphenyl ether
- ☐ HCB (Hexachlorobenzene)
- ☐ Hexachlorobutadiene
- ☐ Alpha hexachlorocyclohexane
- ☐ Beta hexachlorocyclohexane

- ☐ Lindane (gamma hexachlorocyclohexane)
- ☐ Mirex
- ☐ Pentachlorobenzene
- ☐ PCB (Polychlorinated biphenyls)
- ☐ SCCPs (Short chain chlorinated paraffins)
- ☐ Technical endosulfan and its related isomers
- ☐ Tetrabromodiphenyl ether and pentabromodiphenyl ether
- ☐ Toxaphene
- ☐ DDT
- ☐ PFOS/PFOA (Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride)
- ☐ PCP (Pentachlorophenol)
- ☐ PCDD (Polychlorinated dibenzo-p-dioxins)
- ☐ PCDF (Polychlorinated dibenzofurans)
- ☐ Polychlorinated naphthalenes.
- ☐ PeCB (Pentachlorobenzene)
- ☐ None

Persistent Organic Pollutants

Persistent organic pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. This group of priority pollutants consists of pesticides (such as DDT), industrial chemicals (such as polychlorinated biphenyls, PCBs) and unintentional by-products of industrial processes (such as dioxins and furans).

Persistent Organic Pollutants are transported across international boundaries far from their sources, even to regions where they have never been used or produced. The ecosystems and indigenous people of the Arctic are particularly at risk because of the long-range environmental transportation and bio-magnification of these substances. Consequently, persistent organic pollutants pose a threat to the environment and to human health all over the globe.

See more: <http://ec.europa.eu/environment/pops/>

3. Are there other emerging contaminants which are currently receiving attention in your country in relation to soil, groundwater and/or sediments (beside the substances in the list from the Stockholm Convention)?

If so, please write down which emerging contaminants these are. For example:

- ☐ Mineral oil
- ☐ Hormones
- ☐ Asbestos
- ☐ Heavy metals
- ☐ Chlorinated solvents
- ☐ MTBE
- ☐ Dioxanes
- ☐ Antibiotics
- ☐ Others, namely
- ☐ None

EMERGING CONTAMINANTS

Why are these emerging contaminants receiving your special attention?

What was the cause for this attention?

If documents are publicly available and relevant, you may upload these documents.

4. Please describe what kind of problems your country experiences with emerging contaminants in different environmental compartments (e.g. calamities, health problems, ecological problems) and write down what emerging contaminants it is about?

☐ In soil

What emerging contaminants?

Please typify the problem:

☐ In groundwater

What emerging contaminants?

Please typify the problem:

☐ In sediments

What emerging contaminants?

Please typify the problem:



Besides soil, groundwater and/or sediment related problems, is there attention for emerging contaminants in other environmental compartments?

☐ In drinking water What emerging contaminants?

Please typify the problem:

☐ In surface water What emerging contaminants?

Please typify the problem:

☐ In atmosphere What emerging contaminants?

Please typify the problem:

☐ Other, being:

What emerging contaminants?

Please typify the problem:

☐ None, please continue to question 6

If documents are publicly available and relevant, you may upload these documents.

5. Which organisations in your country are dealing with emerging contaminants in the environment and why? (such as research institutes, NGOs, companies, universities, other governmental departments etc.). For example: which organization is responsible for research on emerging contaminants or which organisation has to deal with disasters/issues (e.g. big fires, flooding, spills)? Please write down the organisation and (if available) provide contact information of the relevant persons.

Organisation	Aim of the organisation	Contact information of relevant persons (name, adress, email, phone number)



POLICY AND LEGISLATION

The following questions about policy and legislation are intended for governmental (related) organisations only. If this is not suitable for you or you do not work at such an organisation, please continue the questionnaire at question 9 (technical approach).

We are interested in the existing policy and legislation on emerging contaminants in the EU. We hereby focus on 'curative' policy and legislation, on how to deal with emerging contaminants which are already present in the environment. We explicitly exclude preventive policy, legislation and/or additional regulations (for example REACH).

6. 6A. Is there a policy or legislation on emerging contaminants in your country?

- ☐ In soil
- ☐ In groundwater
- ☐ In sediments

6B. Is there policy or legislation on emerging contaminants for other compartments, which are related to or has an interface with the compartments soil, groundwater and/or sediment?

- ☐ In food
- ☐ In agricultural products
- ☐ In drinking water
- ☐ In surface water
- ☐ In atmosphere
- ☐ Other, being

If so, please describe the relation/interface:

7. 7A. Policy: if there is policy on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions.

Please summarize the policy briefly:

What are the main policy objectives and characteristics?

What are the principles on which the national policy on emerging contaminants is based on (e.g. focus on hotspots, linking occurrence with potential sources, etc.)?

How is this policy implemented (is there legislation)?

What are in your opinion, the strengths and challenges with respect to the current policy in your country?

7B. If there is no such policy, please answer the following questions:

Do you know what's the reason why there is no policy (e.g. lack of urgency, available budget, etc.)?

Provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:

8. 8A. Legislation: If there is legislation on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions:

Summarize the legislation briefly:

What are the main legislation objectives and characteristics?

What are the principles on which the national legislation on emerging contaminants is based on?

How is this legislation implemented?

EMERGING CONTAMINANTS

What are in your opinion the strengths and challenges with respect to the current legislation in your country?

8B. If there is no such legislation, please answer the following questions:

Do you know the reason why there is no legislation (e.g. lack of urgency, available budget, etc.)?

Please provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:



TECHNICAL APPROACH

One of the problems with emerging contaminants is that they are not commonly and systematically measured. Therefore, it is often not known where and in what concentrations emerging contaminants occur.

9. Can you specify how you determine if emerging contaminants occur at a specific site or in a specific area?

10. Does your country/organisation have a list of parameters which are commonly analysed in soil, sediments and groundwater researches on (suspect) locations?

- ☐ If so, answer the following questions:

Please describe or upload which parameters are included on this list:

How was this list established (criteria/approach)?

Is there a procedure to add or delete parameters from this list?

Is one or more of the emerging contaminants listed in question 2 or 3 part of this list of commonly analysed parameters? If so, specify which:

- ☐ If not, how is decided which emerging contaminants must be analysed? Is this dependant on the specific site or area, or are other criteria decisive?

Investigation and analysis.

11. Is there a procedure or strategy (e.g. protocol, approach, methodology) for one or more emerging contaminants on how to investigate this in soil, sediments and/or groundwater?

- ☐ If so, please answer the questions below:

Describe this procedure:

How is this procedure established (what is it based on)?

Does this procedure apply for all emerging contaminants or for one or more specific emerging contaminants? Please describe for which emerging contaminants:

- ☐ If not, would you prefer to have a standard procedure or strategy for emerging contaminants in soil, sediments and/or groundwater? (why, and for which compounds?)

Remediation.

12. Once emerging contaminants are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. For which emerging contaminants do you know or use remediation techniques or approaches, or for which emerging contaminants do you feel the need to have this?

And which remediation techniques are used (e.g. isolation, capping, chemical oxidation, membrane technology)?

Monitoring data.

13. Which cases and/or monitoring data are available?

PFOS/PFOA AS AN EXAMPLE OF EMERGING CONTAMINANTS

PFOS and PFOA are on the Stockholm Convention list, and therefore at EU level recognized as emerging contaminants. In the Netherlands and Flanders, these parameters are considered as 'leading emerging contaminants', among others because of their occurrence in water treatment plants. However, in the Netherlands and in Flanders there is, despite of the societal relevance, no procedure on how to deal with these emerging contaminants. It is therefore important to learn more about these parameters, especially about their presence and behaviour in soil, groundwater and/or sediments. We are interested in suggestions on how to deal with PFOS and PFOA in soil, groundwater and sediments as an example of emerging contaminants. To explore the status of PFOS and PFOA in other EU countries, they are explored here in more detail.

PFOS/PFOA experts

If you know an expert on PFOS/PFOA in your network, we appreciate it if you let this expert also fill in the questions below.

14. Has your country been facing PFOS/PFOA in soil, sediments and/or groundwater?

☐ If not, go to question 17.

☐ If so, please answer the following questions:

What is your procedure when PFOS/PFOA is present in the environment?

At which locations (landfill, fire station, airports, etc.) does it occur?

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (e.g. landfill, fire station, airport)?

Specific sources PFOS/PFOA

15. Fire-fighting foam is a known source of PFOS/PFOA. Are you aware of calamities where fires were extinguished with a PFOS/PFOA containing foam? What was the procedure after this foam entered the environment? Has an investigation been performed? Which strategy was used?

Other activities like de-icing, textile treatment or metal surface treatment can also cause PFOS/PFOA contamination. Do you have experience with these activities in relation to the occurrence of PFOS/PFOA?

Remediation of PFOS/PFOA.

16. Once PFOS/PFOA are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. Do you know of any remediation techniques or approaches for PFOS/PFOA? And which remediation techniques are used for PFOS/PFOA (e.g. isolation, capping, chemical oxidation, membrane technology)?

Surface water and drinking water.

17. Has your country been facing PFOS/PFOA in surface water and/or drinking water?

☐ If not, go to question 18.

☐ If so, please answer the following questions:

At which locations (water treatment plants, sewage discharge points, etc.) does it occur?

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (water treatment plants, sewage discharge points, etc.) ?

SUGGESTIONS FOR FOLLOW-UP

18. Would you find a (national or European) strategy or approach on how to deal with emerging contaminants helpful?

19. What information do you need to develop a strategy on how to deal with emerging contaminants?

20. Do you have specific questions about emerging contaminants in your country (like behaviour, route of exposure, occurrence, toxicity, remediation techniques, etc.)?

21. What would you like to know from colleagues from other networks? (we will endeavour to provide this information in the questionnaire report).

- ☐ info about specific legislation
- ☐ info about policy
- ☐ info about remediation techniques and strategies
- ☐ info about environmental (soil / groundwater / sediment) investigation strategies
- ☐ info about scientific research

If so, please specify:

REFERENCES

Please give the most important references (leading literature, documents, website, projects, and case studies) that could be relevant for explaining your national approach on emerging contaminants or PFOS/PFOA.

Documents, links or other information, which may be useful in this survey, can be uploaded to the following e-mail address: info@emergingcontaminants.eu

FINAL QUESTIONS

Do you have any questions or suggestions for the authors of this questionnaire?

Are you interested in the establishment of a network focussing on emerging contaminants?

Are you interested in being informed about developments around this questionnaire? Please provide your contact information (question 0).

For more information or questions regarding this questionnaire you can send an email to info@emergingcontaminants.eu. Or you can contact us at phone number +31 570-665878 (Arne Alphenaar, TTE, the Netherlands) or +31 570-697184 (Martijn van Houten, Witteveen+Bos, the Netherlands).



Questionnaire on Contaminated Land Management in Europe

Emerging contaminants

AIM OF THIS QUESTIONNAIRE

With increasing frequency countries and organisations are faced with chemicals that have not been considered as 'contaminants' before. Some of these chemicals could be a potential risk to humans and/or the environment. These are the so-called 'emerging contaminants'. Roughly defined by the United States Geological Survey as "any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects".

Characteristic for emerging contaminants is that too little is known about the occurrence, the actual risks and the approach to formulate appropriate policy and legislation. To properly identify how to deal with emerging contaminants knowledge, awareness and understanding is necessary.

Commissioned by the Ministry of I&M / RWS (Netherlands) and the OVAM (Flanders), this questionnaire has been developed. This questionnaire aims to wrap up available knowledge and experience related to legislation, governance and policy. The focus is on the presence and the curative policy on emerging contaminants that are already present in the soil, groundwater and sediments.

This questionnaire is a first step to decide whether it is necessary to develop an effective approach on how to deal with emerging contaminants. The results of this inventory will be shared and discussed. Based on this discussion a decision is made whether the development of a strategy on how to deal with emerging contaminants is necessary.

APPROACH

The group of emerging contaminants is very diverse in terms of toxicity, behaviour, remediation/treatment technique and so forth. As a consequence, the dimensions of the problem are not clear. Also the current knowledge and especially the actual approaches on how to deal with emerging contaminants in different countries are not well known.



DDT DDE DDD



PFOS



NANO PARTICLES



Characteristics of emerging contaminants

The various emerging contaminants have in common that there is much uncertainty about them, which leads to the absence of a strategy and policy. The following observations about emerging contaminants are:

- More than 2100 scientific studies have shown that they pose a potential risk to humans, plants and / or animals. However, there's a lack of knowledge of the practical implications;
- The emerging contaminants are not examined in regular environmental investigation. This leads to a lack of data;
- As a result of a lack of data, little is known about the practical situation and risks in the soil, sediment and groundwater system;
- Appropriate strategies and technologies to control existing contaminants are not in development;
- Uncertainty about legal and financial consequences of (potential) contamination will hamper an efficient approach.

This questionnaire aims at the policy and legislation in the European Union, related to man-made emerging contaminants that already are present in the environment in the compartments soil, groundwater and sediment. It is not about preventive legislation (REACH), nor about the application of emerging contaminants.

Therefore we distinguish the following themes in the questionnaire:

- Awareness of emerging contaminants (questions 1 - 5);
- Policy and legislation related to emerging contaminants (questions 6 - 8);
- Technical approach (questions 9 - 13);
- Focus on PFOS and PFOA as a 'pilot' emerging contaminants (questions 14 - 17);
- Suggestions for follow-up (questions 18 - 21).

PROCESS AND RESULTS

The questionnaire is spread among the members of the Common Forum and. Also members of the related network organisations SedNet and NICOLE, which are also participating in the Common Forum, are asked to fill in this questionnaire.

For this inventory we developed a website (www.emergingcontaminants.eu) and this questionnaire. The website can be used to upload relevant documents that may be used and shared publicly.

Please feel free to send the web-link or this form to colleagues or related organisations if you think that they can give valuable information. It is also possible that not all questions can be answered. Please skip those questions or contact a colleague for those questions! The form can be saved and edited or filled later on.

Participants will be informed about the results of the questionnaire. Results of this questionnaire will be treated anonymously. Information such as name, function and organisation is not necessary, but might be helpful for us to interpret the results.

It is possible that you cannot answer all questions. Please skip those questions and continue the questionnaire. You can also send this form to a colleague. The form can be saved and edited or filled later on.

0. Fill in your country and function:

Country

Organisation:

Function

Expertise

Optional:

Telephone no.

Email

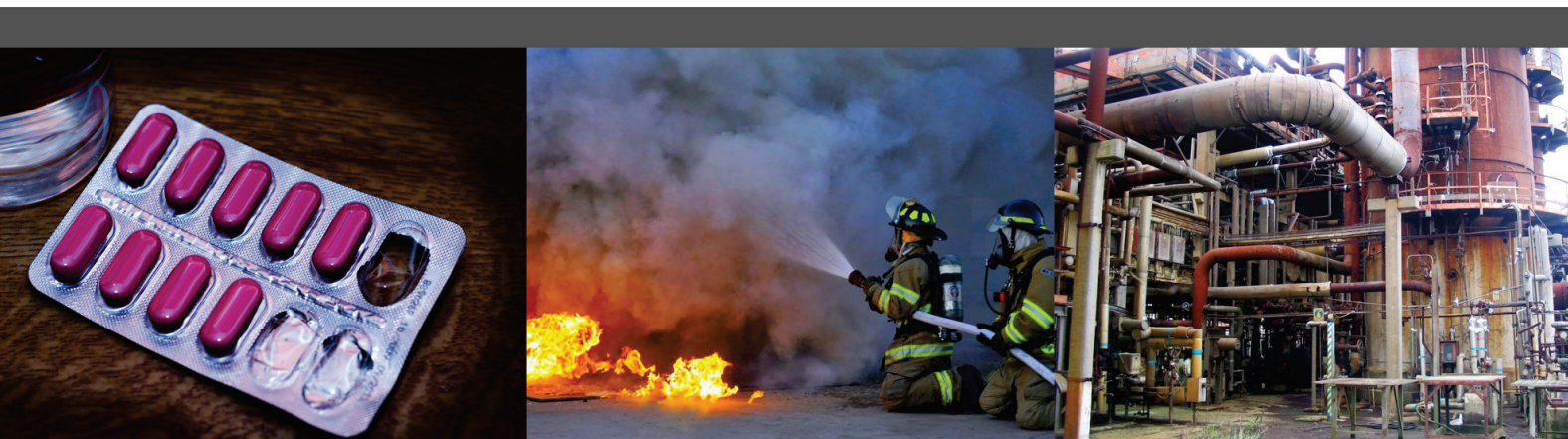
Unless you tick the next boxes, answers will be treated strictly anonymously.

- ☒ I have no objection that my answers will be related in a report to me.
- ☒ I have no objection that my answers will be related in a report to my organization.
- ☒ I have no objection when the documents I upload will be related in a report to me or my organization.
- ☒ I have no objection when the documents I upload will be accessible to other people via a website.

Documents, links or other information, which may be useful in this survey, can be sent to the following e-mail address:

Info@emergingcontaminants.eu

Also questions regarding this questionnaire can be sent to info@emergingcontaminants.eu. You can also contact us at phone number +31 570-665878 (Arne Alphenaar, TTE) or +31 570-697184 (Martijn van Houten, Witteveen+Bos).



AWARENESS

Definition by the United States Geological Survey:

“Any synthetic or naturally occurring chemical that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and(or) human health effects”.

1. Do you endorse the given definition of ‘emerging contaminants’?

☒ Yes, continue with question 2

☐ No, please give a better definition or comment on this definition:

The number of emerging contaminants is extensive. Therefore we further focus on one special group of emerging contaminants, the Persistent Organic Pollutants (POP). A number of Persistent Organic Pollutants are included in The Stockholm Convention on Persistent Organic Pollutants.

Stockholm Convention

This is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. In the Stockholm Convention chemicals targeted by the Convention are listed.

2. Please indicate which POP’s from the Stockholm Convention you are familiar with in terms of contaminated land management/river basin management (soil, groundwater, sediments):

- ☐ Aldrin
- ☐ Bromo diphenylethers
- ☐ Chlordane
- ☐ Chlordecone
- ☐ HCB (Hexabromocyclododecane)
- ☐ Dicofol
- ☐ Dieldrin
- ☐ Endrin
- ☐ Heptachlor
- ☐ Hexabromobiphenyl
- ☐ Hexabromodiphenyl ether and heptabromodiphenyl ether
- ☐ HCB (Hexachlorobenzene)
- ☐ Hexachlorobutadiene
- ☐ Alpha hexachlorocyclohexane
- ☐ Beta hexachlorocyclohexane

- ☐ Lindane (gamma hexachlorocyclohexane)
- ☐ Mirex
- ☐ Pentachlorobenzene
- ☐ PCB (Polychlorinated biphenyls)
- ☐ SCCPs (Short chain chlorinated paraffins)
- ☐ Technical endosulfan and its related isomers
- ☐ Tetrabromodiphenyl ether and pentabromodiphenyl ether
- ☐ Toxaphene
- ☐ DDT
- ☒ PFOS/PFOA (Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonvl fluoride)
- ☐ PCP (Pentachlorophenol)
- ☐ PCDD (Polychlorinated dibenzo-p-dioxins)
- ☐ PCDF (Polychlorinated dibenzofurans)
- ☐ Polychlorinated naphthalenes.
- ☐ PeCB (Pentachlorobenzene)
- ☐ None

Persistent Organic Pollutants

Persistent organic pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. This group of priority pollutants consists of pesticides (such as DDT), industrial chemicals (such as polychlorinated biphenyls, PCBs) and unintentional by-products of industrial processes (such as dioxins and furans).

Persistent Organic Pollutants are transported across international boundaries far from their sources, even to regions where they have never been used or produced. The ecosystems and indigenous people of the Arctic are particularly at risk because of the long-range environmental transportation and bio-magnification of these substances. Consequently, persistent organic pollutants pose a threat to the environment and to human health all over the globe.

See more: <http://ec.europa.eu/environment/pops/>

3. Are there other emerging contaminants which are currently receiving attention in your country in relation to soil, groundwater and/or sediments (beside the substances in the list from the Stockholm Convention)?

If so, please write down which emerging contaminants these are. For example:

- ☐ Mineral oil
- ☐ Hormones
- ☒ Asbestos
- ☒ Heavy metals
- ☒ Chlorinated solvents
- ☐ MTBE
- ☐ Dioxanes
- ☐ Antibiotics
- ☐ Others, namely
- ☐ None

EMERGING CONTAMINANTS

Why are these emerging contaminants receiving your special attention?

PFASs such as PFOS and PFOA

What was the cause for this attention?

More and more sites found or reported to be contaminated

If documents are publicly available and relevant, you may upload these documents.

4. Please describe what kind of problems your country experiences with emerging contaminants in different environmental compartments (e.g. calamities, health problems, ecological problems) and write down what emerging contaminants it is about?

☒ In soil

What emerging contaminants?

PFASs

Please typify the problem:

Environmental and health impact
No Australian guidelines and health values yet
Lack of clear regulators policy or regulation or guidelines

☒ In groundwater

What emerging contaminants?

PFASs

Please typify the problem:

As above

☒ In sediments

What emerging contaminants?

PFASs

Please typify the problem:

As above



Besides soil, groundwater and/or sediment related problems, is there attention for emerging contaminants in other environmental compartments?

☒ In drinking water What emerging contaminants?

PFASs

Please typify the problem:

As above

☒ In surface water What emerging contaminants?

PFASs

Please typify the problem:

As above

☒ In atmosphere What emerging contaminants?

PFASs

Please typify the problem:

Although it is now well documented that PFASs are transported in the air to remote areas and one of the pathways for entry of PFASs into the body is via air and

☐ Other, being:

What emerging contaminants?

Please typify the problem:

☐ None, please continue to question 6

If documents are publicly available and relevant, you may upload these documents.

EMERGING CONTAMINANTS

5. Which organisations in your country are dealing with emerging contaminants in the environment and why? (such as research institutes, NGOs, companies, universities, other governmental departments etc.). For example: which organization is responsible for research on emerging contaminants or which organisation has to deal with disasters/issues (e.g. big fires, flooding, spills)? Please write down the organisation and (if available) provide contact information of the relevant persons.

Organisation	Aim of the organisation	Contact information of relevant persons (name, adress, email, phone number)
Department of Environ	Environment protection	Dr Jimmy Seow Department of Environment Regulation 168 St georges Tce



POLICY AND LEGISLATION

The following questions about policy and legislation are intended for governmental (related) organisations only. If this is not suitable for you or you do not work at such an organisation, please continue the questionnaire at question 9 (technical approach).

We are interested in the existing policy and legislation on emerging contaminants in the EU. We hereby focus on 'curative' policy and legislation, on how to deal with emerging contaminants which are already present in the environment. We explicitly exclude preventive policy, legislation and/or additional regulations (for example REACH).

6. 6A. Is there a policy or legislation on emerging contaminants in your country?

- ☒ In soil
- ☒ In groundwater
- ☒ In sediments

6B. Is there policy or legislation on emerging contaminants for other compartments, which are related to or has an interface with the compartments soil, groundwater and/or sediment?

- ☐ In food
- ☐ In agricultural products
- ☐ In drinking water
- ☒ In surface water
- ☐ In atmosphere
- ☐ Other, being

If so, please describe the relation/interface:

There are currently no formal policy and regulation for PFASs for the above ticked boxes.

7. 7A. Policy: if there is policy on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions.

Please summarize the policy briefly:

In Australia, currently there:

1. Draft Commonwealth Dept of Environment Derived Guideline Values for PFOS in freshwater recently released for regulators consultation (NB; there are Commonwealth

What are the main policy objectives and characteristics?

Guidance for contaminated sites and health impact values

What are the principles on which the national policy on emerging contaminants is based on (e.g. focus on hotspots, linking occurrence with potential sources, etc.)?

As described above in Question 4.

How is this policy implemented (is there legislation)?

Policy and guidelines are still been developed which may or may not lead to legislation or regulation. Early days.

What are in your opinion, the strengths and challenges with respect to the current policy in your country?

Policy makers and regulators beginning to appreciate the extent and degree of the PFASs impact upon the environment and human health. The challenges is that there is no much research on the subject matter as compared to those in the US, Canada and the EU.

7B. If there is no such policy, please answer the following questions:

Do you know what's the reason why there is no policy (e.g. lack of urgency, available budget, etc.)?

Government did not fully appreciate the issue until recently due to three states (Queensland, NSW and Victoria) now with reported sites contaminated with PFASs causing public concerns.
Qld - Defence Oakey Army sites

Provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:

1. Educating government, commercial users and the community on the issues of PFASs impact upon the environment and human.
2. Clear policy and legislation to deal with the PFASs issue.
3. Research upon its remediation and treatment to prevent and mitigate the risk of

8. 8A. Legislation: If there is legislation on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions:

Summarize the legislation briefly:

See above other. Australia has yet to rectify Stockholm Convention to include PFOS into Annex 2

What are the main legislation objectives and characteristics?

NA

What are the principles on which the national legislation on emerging contaminants is based on?

Commonwealth or national government party to international agreement, protocols, treatise etc and the state government is the main implementer of that agreement, rectification, party to commitments etc

How is this legislation implemented?

As described above

EMERGING CONTAMINANTS

What are in your opinion the strengths and challenges with respect to the current legislation in your country?

8B. If there is no such legislation, please answer the following questions:

Do you know the reason why there is no legislation (e.g. lack of urgency, available budget, etc.)?

Please provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:



TECHNICAL APPROACH

One of the problems with emerging contaminants is that they are not commonly and systematically measured. Therefore, it is often not known where and in what concentrations emerging contaminants occur.

9. Can you specify how you determine if emerging contaminants occur at a specific site or in a specific area?

When it is reported to the regulators by requirement of law such as the Contaminated Sites Act or when regulators proactively audit premises which may be contaminated or affected. As mentioned above because many regulators are aware of the PFASs issue until recently the contamination of PFASs in soil and water was not actively looked into.

10. Does your country/organisation have a list of parameters which are commonly analysed in soil, sediments and groundwater researches on (suspect) locations?

☒ If so, answer the following questions:

Please describe or upload which parameters are included on this list:

See the Commonwealth Department of Environment NEPM guidelines for contaminated soil and water.

How was this list established (criteria/approach)?

By a committee of the Department of Environment with informed peer review

Is there a procedure to add or delete parameters from this list?

Yes - per the procedure of the above said Committee policy and procedure and then followed by stakeholder agencies both Commonwealth and state

Is one or more of the emerging contaminants listed in question 2 or 3 part of this list of commonly analysed parameters? If so, specify which:

PFASs is now been analysed more and more in soil and groundwater for its degree of impact and risks.

- ☐ If not, how is decided which emerging contaminants must be analysed? Is this dependant on the specific site or area, or are other criteria decisive?

Investigation and analysis.

11. Is there a procedure or strategy (e.g. protocol, approach, methodology) for one or more emerging contaminants on how to investigate this in soil, sediments and/or groundwater?

- ☒ If so, please answer the questions below:

Describe this procedure:

Per the respective state environmental regulator soil and groundwater investigation policy and procedures.

How is this procedure established (what is it based on)?

Per the NEPM policy and process to harmonize state regulators approach and methodology

Does this procedure apply for all emerging contaminants or for one or more specific emerging contaminants? Please describe for which emerging contaminants:

Yes and on case by case basis on risk principles.

- ☐ If not, would you prefer to have a standard procedure or strategy for emerging contaminants in soil, sediments and/or groundwater? (why, and for which compounds?)

Remediation.

12. Once emerging contaminants are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. For which emerging contaminants do you know or use remediation techniques or approaches, or for which emerging contaminants do you feel the need to have this?

Currently there are only trials and pilot scheme for treating and remediation of soils and water contaminated with PFOS and PFOA

And which remediation techniques are used (e.g. isolation, capping, chemical oxidation, membrane technology)?

Monitoring data.

13. Which cases and/or monitoring data are available?

Several for the sites in Qld, NSW and Victoria as mentioned above but not sure those data will be released to non regulators yet or even regulators in other states because of the sensitivity and community concerns.

PFOS/PFOA AS AN EXAMPLE OF EMERGING CONTAMINANTS

PFOS and PFOA are on the Stockholm Convention list, and therefore at EU level recognized as emerging contaminants. In the Netherlands and Flanders, these parameters are considered as 'leading emerging contaminants', among others because of their occurrence in water treatment plants. However, in the Netherlands and in Flanders there is, despite of the societal relevance, no procedure on how to deal with these emerging contaminants. It is therefore important to learn more about these parameters, especially about their presence and behaviour in soil, groundwater and/or sediments. We are interested in suggestions on how to deal with PFOS and PFOA in soil, groundwater and sediments as an example of emerging contaminants. To explore the status of PFOS and PFOA in other EU countries, they are explored here in more detail.

PFOS/PFOA experts

If you know an expert on PFOS/PFOA in your network, we appreciate it if you let this expert also fill in the questions below.

14. Has your country been facing PFOS/PFOA in soil, sediments and/or groundwater?

☐ If not, go to question 17.

☒ If so, please answer the following questions:

What is your procedure when PFOS/PFOA is present in the environment?

See above info.

At which locations (landfill, fire station, airports, etc.) does it occur?

See above info

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (e.g. landfill, fire station, airport)?

Specific sources PFOS/PFOA

15. Fire-fighting foam is a known source of PFOS/PFOA. Are you aware of calamities where fires were extinguished with a PFOS/PFOA containing foam? What was the procedure after this foam entered the environment? Has an investigation been performed? Which strategy was used?

See comment about Qld DEHP foam policy of which I am a co-author

Other activities like de-icing, textile treatment or metal surface treatment can also cause PFOS/PFOA contamination. Do you have experience with these activities in relation to the occurrence of PFOS/PFOA?

Very much aware of them but no policy yet - see above

Remediation of PFOS/PFOA.

16. Once PFOS/PFOA are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. Do you know of any remediation techniques or approaches for PFOS/PFOA? And which remediation techniques are used for PFOS/PFOA (e.g. isolation, capping, chemical oxidation, membrane technology)?

See above discussion

Am well versed with the various methods but many are at lab experiment or proof of concept stage or trials.

Surface water and drinking water.

17. Has your country been facing PFOS/PFOA in surface water and/or drinking water?

☐ If not, go to question 18.

☒ If so, please answer the following questions:

At which locations (water treatment plants, sewage discharge points, etc.) does it occur?

In Australia, so far we know of sites which are contaminated with PFASs are due to use of fire fighting foams such as at airport, Defence sites and firefighting facilities. There are emerging of waste water treatment plants with PFASs. This is just the beginning for regulators as the issue of PFASs is more and more known and understood

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (water treatment plants, sewage discharge points, etc.) ?

See above discussion

SUGGESTIONS FOR FOLLOW-UP

18. Would you find a (national or European) strategy or approach on how to deal with emerging contaminants helpful?

Yes. Am well versed with the various drinking water and surface waters values of EU, US, Canada and UK

19. What information do you need to develop a strategy on how to deal with emerging contaminants?

1. Current policy and legislation
2. Guidelines such as drinking water, health values etc.

20. Do you have specific questions about emerging contaminants in your country (like behaviour, route of exposure, occurrence, toxicity, remediation techniques, etc.)?

See above

21. What would you like to know from colleagues from other networks? (we will endeavour to provide this information in the questionnaire report).

- ☒ info about specific legislation
- ☒ info about policy
- ☒ info about remediation techniques and strategies
- ☒ info about environmental (soil / groundwater / sediment) investigation strategies
- ☒ info about scientific research

If so, please specify:

REFERENCES

Please give the most important references (leading literature, documents, website, projects, and case studies) that could be relevant for explaining your national approach on emerging contaminants or PFOS/PFOA.

Documents, links or other information, which may be useful in this survey, can be uploaded to the following e-mail address: info@emergingcontaminants.eu

FINAL QUESTIONS

Do you have any questions or suggestions for the authors of this questionnaire?

Are you interested in the establishment of a network focussing on emerging contaminants?

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Questionnaire on Contaminated Land Management in Europe

Emerging contaminants

AIM OF THIS QUESTIONNAIRE

With increasing frequency countries and organisations are faced with chemicals that have not been considered as 'contaminants' before. Some of these chemicals could be a potential risk to humans and/or the environment. These are the so-called 'emerging contaminants'. Roughly defined by the United States Geological Survey as "any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects".

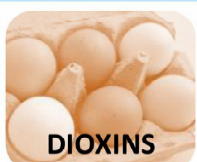
Characteristic for emerging contaminants is that too little is known about the occurrence, the actual risks and the approach to formulate appropriate policy and legislation. To properly identify how to deal with emerging contaminants knowledge, awareness and understanding is necessary.

Commissioned by the Ministry of I&M / RWS (Netherlands) and the OVAM (Flanders), this questionnaire has been developed. This questionnaire aims to wrap up available knowledge and experience related to legislation, governance and policy. The focus is on the presence and the curative policy on emerging contaminants that are already present in the soil, groundwater and sediments.

This questionnaire is a first step to decide whether it is necessary to develop an effective approach on how to deal with emerging contaminants. The results of this inventory will be shared and discussed. Based on this discussion a decision is made whether the development of a strategy on how to deal with emerging contaminants is necessary.

APPROACH

The group of emerging contaminants is very diverse in terms of toxicity, behaviour, remediation/treatment technique and so forth. As a consequence, the dimensions of the problem are not clear. Also the current knowledge and especially the actual approaches on how to deal with emerging contaminants in different countries are not well known.



DDT DDE DDD



PFOS



NANO PARTICLES



Characteristics of emerging contaminants

The various emerging contaminants have in common that there is much uncertainty about them, which leads to the absence of a strategy and policy. The following observations about emerging contaminants are:

- More than 2100 scientific studies have shown that they pose a potential risk to humans, plants and / or animals. However, there's a lack of knowledge of the practical implications;
- The emerging contaminants are not examined in regular environmental investigation. This leads to a lack of data;
- As a result of a lack of data, little is known about the practical situation and risks in the soil, sediment and groundwater system;
- Appropriate strategies and technologies to control existing contaminants are not in development;
- Uncertainty about legal and financial consequences of (potential) contamination will hamper an efficient approach.

This questionnaire aims at the policy and legislation in the European Union, related to man-made emerging contaminants that already are present in the environment in the compartments soil, groundwater and sediment. It is not about preventive legislation (REACH), nor about the application of emerging contaminants.

Therefore we distinguish the following themes in the questionnaire:

- Awareness of emerging contaminants (questions 1 - 5);
- Policy and legislation related to emerging contaminants (questions 6 - 8);
- Technical approach (questions 9 - 13);
- Focus on PFOS and PFOA as a 'pilot' emerging contaminants (questions 14 - 17);
- Suggestions for follow-up (questions 18 - 21).

PROCESS AND RESULTS

The questionnaire is spread among the members of the Common Forum and. Also members of the related network organisations SedNet and NICOLE, which are also participating in the Common Forum, are asked to fill in this questionnaire.

For this inventory we developed a website (www.emergingcontamints.eu) and this questionnaire. The website can be used to upload relevant documents that may be used and shared publicly.

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0. Fill in your country and function:

Country

Organisation:

Function

Expertise

Optional:

Telephone no.

Email

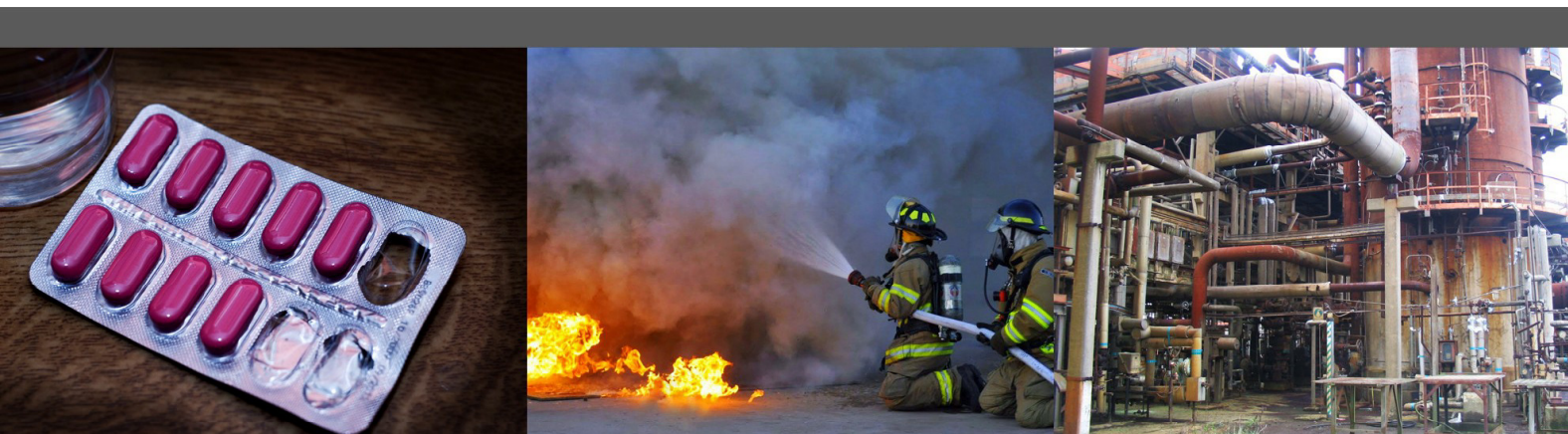
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- ☒ I have no objection that my answers will be related in a report to me.
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AWARENESS

Definition by the United States Geological Survey:

“Any synthetic or naturally occurring chemical that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and(or) human health effects”.

1. Do you endorse the given definition of ‘emerging contaminants’?

- ☒ Yes, continue with question 2
- ☐ No, please give a better definition or comment on this definition:

The number of emerging contaminants is extensive. Therefore we further focus on one special group of emerging contaminants, the Persistent Organic Pollutants (POP). A number of Persistent Organic Pollutants are included in The Stockholm Convention on Persistent Organic Pollutants.

Stockholm Convention

This is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. In the Stockholm Convention chemicals targeted by the Convention are listed.

2. Please indicate which POP's from the Stockholm Convention you are familiar with in terms of contaminated land management/river basin management (soil, groundwater, sediments):

- ☒ Aldrin
- ☐ Bromo diphenylethers
- ☒ Chlordane
- ☐ Chlordecone
- ☐ HCB (Hexabromocyclohexane)
- ☐ Dicofol
- ☐ Dieldrin
- ☐ Endrin
- ☐ Heptachlor
- ☐ Hexabromobiphenyl
- ☐ Hexabromodiphenyl ether and heptabromodiphenyl ether
- ☐ HCB (Hexachlorobenzene)
- ☐ Hexachlorobutadiene
- ☐ Alpha hexachlorocyclohexane
- ☐ Beta hexachlorocyclohexane

- ☒ Lindane (gamma hexachlorocyclohexane)
- ☒ Mirex
- ☐ Pentachlorobenzene
- ☒ PCB (Polychlorinated biphenyls)
- ☐ SCCPs (Short chain chlorinated paraffins)
- ☐ Technical endosulfan and its related isomers
- ☐ Tetrabromodiphenyl ether and pentabromodiphenyl ether
- ☐ Toxaphene
- ☒ DDT
- ☒ PFOS/PFOA (Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonfyl fluoride)
- ☐ PCP (Pentachlorophenol)
- ☐ PCDD (Polychlorinated dibenzo-p-dioxins)
- ☐ PCDF (Polychlorinated dibenzofurans)
- ☐ Polychlorinated naphthalenes.
- ☐ PeCB (Pentachlorobenzene)
- ☐ None

Persistent Organic Pollutants

Persistent organic pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. This group of priority pollutants consists of pesticides (such as DDT), industrial chemicals (such as polychlorinated biphenyls, PCBs) and unintentional by-products of industrial processes (such as dioxins and furans).

Persistent Organic Pollutants are transported across international boundaries far from their sources, even to regions where they have never been used or produced. The ecosystems and indigenous people of the Arctic are particularly at risk because of the long-range environmental transportation and bio-magnification of these substances. Consequently, persistent organic pollutants pose a threat to the environment and to human health all over the globe.

See more: <http://ec.europa.eu/environment/pops/>

3. Are there other emerging contaminants which are currently receiving attention in your country in relation to soil, groundwater and/or sediments (beside the substances in the list from the Stockholm Convention)?

If so, please write down which emerging contaminants these are. For example:

- ☐ Mineral oil
- ☐ Hormones
- ☐ Asbestos
- ☐ Heavy metals
- ☐ Chlorinated solvents
- ☐ MTBE
- ☐ Dioxanes
- ☐ Antibiotics
- ☒ Others, namely Pesticides. The other here mentioned are dealt with and there
- ☐ None

EMERGING CONTAMINANTS

Why are these emerging contaminants receiving your special attention?

a criteria of 01, ug/l

What was the cause for this attention?

frequently found in water abstraction wells

If documents are publicly available and relevant, you may upload these documents.

4. Please describe what kind of problems your country experiences with emerging contaminants in different environmental compartments (e.g. calamities, health problems, ecological problems) and write down what emerging contaminants it is about?

☐ In soil

What emerging contaminants?

Please typify the problem:

☒ In groundwater

What emerging contaminants?

various pesticides, PFAS

Please typify the problem:

health problems from exceeding guideline values,
ecological problems and threat to surface water

☐ In sediments

What emerging contaminants?

Please typify the problem:



Besides soil, groundwater and/or sediment related problems, is there attention for emerging contaminants in other environmental compartments?

☒ In drinking water What emerging contaminants?

Hormones

Please typify the problem:

mainly waste water related

☒ In surface water What emerging contaminants?

pesticides

Please typify the problem:

ecological impact

☐ In atmosphere What emerging contaminants?

Please typify the problem:

☐ Other, being:

What emerging contaminants?

Please typify the problem:

☐ None, please continue to question 6

If documents are publicly available and relevant, you may upload these documents.

5. Which organisations in your country are dealing with emerging contaminants in the environment and why? (such as research institutes, NGOs, companies, universities, other governmental departments etc.). For example: which organization is responsible for research on emerging contaminants or which organisation has to deal with disasters/issues (e.g. big fires, flooding, spills)? Please write down the organisation and (if available) provide contact information of the relevant persons.

Organisation	Aim of the organisation	Contact information of relevant persons (name, adress, email, phone number)
Danish EPA	Environmental protecti	Jette Rud Heltved Miljøstyrelsen www.mst.dk
Aarhus Univeristet Det J	Research	Niels Henrik Spliid Aarhus Universitet http://food.au.dk/en/
Technical University of	Research	Elsa Nielsen DTU Food http://www.food.dtu.dk/english
Danish Health and Mec	Public health	www.sst.dk Axel Heides Gade 1 2300 København S Telefon: 72 22 74 00 E-mail: sst@sst.dk



POLICY AND LEGISLATION

The following questions about policy and legislation are intended for governmental (related) organisations only. If this is not suitable for you or you do not work at such an organisation, please continue the questionnaire at question 9 (technical approach).

We are interested in the existing policy and legislation on emerging contaminants in the EU. We hereby focus on 'curative' policy and legislation, on how to deal with emerging contaminants which are already present in the environment. We explicitly exclude preventive policy, legislation and/or additional regulations (for example REACH).

6. 6A. Is there a policy or legislation on emerging contaminants in your country?

- ☐ In soil
- ☐ In groundwater
- ☐ In sediments

6B. Is there policy or legislation on emerging contaminants for other compartments, which are related to or has an interface with the compartments soil, groundwater and/or sediment?

- ☐ In food
- ☐ In agricultural products
- ☐ In drinking water
- ☐ In surface water
- ☐ In atmosphere
- ☐ Other, being

If so, please describe the relation/interface:

The Danish EPA maintains the following registers:
LOUS, list of unknown substances
PROBAS, product registry database

7. 7A. Policy: if there is policy on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions.

Please summarize the policy briefly:

What are the main policy objectives and characteristics?

What are the principles on which the national policy on emerging contaminants is based on (e.g. focus on hotspots, linking occurrence with potential sources, etc.)?

How is this policy implemented (is there legislation)?

What are in your opinion, the strengths and challenges with respect to the current policy in your country?

7B. If there is no such policy, please answer the following questions:

Do you know what's the reason why there is no policy (e.g. lack of urgency, available budget, etc.)?

Provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:

8. 8A. Legislation: If there is legislation on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions:

Summarize the legislation briefly:

What are the main legislation objectives and characteristics?

What are the principles on which the national legislation on emerging contaminants is based on?

How is this legislation implemented?

EMERGING CONTAMINANTS

What are in your opinion the strengths and challenges with respect to the current legislation in your country?

8B. If there is no such legislation, please answer the following questions:

Do you know the reason why there is no legislation (e.g. lack of urgency, available budget, etc.)?

Please provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:



TECHNICAL APPROACH

One of the problems with emerging contaminants is that they are not commonly and systematically measured. Therefore, it is often not known where and in what concentrations emerging contaminants occur.

9. Can you specify how you determine if emerging contaminants occur at a specific site or in a specific area?

By mapping which activities has used what particular substances, and where and in which industries these activities has taken place

10. Does your country/organisation have a list of parameters which are commonly analysed in soil, sediments and groundwater researches on (suspect) locations?

☒ If so, answer the following questions:

Please describe or upload which parameters are included on this list:

<http://mst.dk/media/131857/kvalitetskriterier-jord-og-drikkevand-juni-2015.pdf>

How was this list established (criteria/approach)?

based on LOAEL from lab studies

Is there a procedure to add or delete parameters from this list?

decission by specialist committee

Is one or more of the emerging contaminants listed in question 2 or 3 part of this list of commonly analysed parameters? If so, specify which:

- ☐ If not, how is decided which emerging contaminants must be analysed? Is this dependant on the specific site or area, or are other criteria decisive?

Investigation and analysis.

11. Is there a procedure or strategy (e.g. protocol, approach, methodology) for one or more emerging contaminants on how to investigate this in soil, sediments and/or groundwater?

- ☐ If so, please answer the questions below:

Describe this procedure:

How is this procedure established (what is it based on)?

Does this procedure apply for all emerging contaminants or for one or more specific emerging contaminants? Please describe for which emerging contaminants:

- ☐ If not, would you prefer to have a standard procedure or strategy for emerging contaminants in soil, sediments and/or groundwater? (why, and for which compounds?)

Remediation.

12. Once emerging contaminants are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. For which emerging contaminants do you know or use remediation techniques or approaches, or for which emerging contaminants do you feel the need to have this?

Pesticides
Chlorinated
solvents
Gasoline (C5-

And which remediation techniques are used (e.g. isolation, capping, chemical oxidation, membrane technology)?

Soil removal (excavation or drilling) Short Average None High
Containment Short High None Average
Fracturing combined with other technologies (1) High (3) High (3) Low (3)
Passive ventilation Long Low Low Low

Monitoring data.

13. Which cases and/or monitoring data are available?

investigation drillings and samples are stored for public investigations in a national database from 2015 and onwards

PFOS/PFOA AS AN EXAMPLE OF EMERGING CONTAMINANTS

PFOS and PFOA are on the Stockholm Convention list, and therefore at EU level recognized as emerging contaminants. In the Netherlands and Flanders, these parameters are considered as 'leading emerging contaminants', among others because of their occurrence in water treatment plants. However, in the Netherlands and in Flanders there is, despite of the societal relevance, no procedure on how to deal with these emerging contaminants. It is therefore important to learn more about these parameters, especially about their presence and behaviour in soil, groundwater and/or sediments. We are interested in suggestions on how to deal with PFOS and PFOA in soil, groundwater and sediments as an example of emerging contaminants. To explore the status of PFOS and PFOA in other EU countries, they are explored here in more detail.

PFOS/PFOA experts

If you know an expert on PFOS/PFOA in your network, we appreciate it if you let this expert also fill in the questions below.

14. Has your country been facing PFOS/PFOA in soil, sediments and/or groundwater?

☐ If not, go to question 17.

☒ If so, please answer the following questions:

What is your procedure when PFOS/PFOA is present in the environment?

P&T, registering land as contaminated

At which locations (landfill, fire station, airports, etc.) does it occur?

airports, firestations, carpetindustry/ producers, chromium plating, landfills

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (e.g. landfill, fire station, airport)?

no historical monitoring at contaminated sites with PFAS

Specific sources PFOS/PFOA

15. Fire-fighting foam is a known source of PFOS/PFOA. Are you aware of calamities where fires were extinguished with a PFOS/PFOA containing foam? What was the procedure after this foam entered the environment? Has an investigation been performed? Which strategy was used?

No

Other activities like de-icing, textile treatment or metal surface treatment can also cause PFOS/PFOA contamination. Do you have experience with these activities in relation to the occurrence of PFOS/PFOA?

chromium plating

Remediation of PFOS/PFOA.

16. Once PFOS/PFOA are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. Do you know of any remediation techniques or approaches for PFOS/PFOA? And which remediation techniques are used for PFOS/PFOA (e.g. isolation, capping, chemical oxidation, membrane technology)?

P&T

Surface water and drinking water.

17. Has your country been facing PFOS/PFOA in surface water and/or drinking water?

☒ If not, go to question 18.

☐ If so, please answer the following questions:

At which locations (water treatment plants, sewage discharge points, etc.) does it occur?

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (water treatment plants, sewage discharge points, etc.) ?

SUGGESTIONS FOR FOLLOW-UP

18. Would you find a (national or European) strategy or approach on how to deal with emerging contaminants helpful?

yes

19. What information do you need to develop a strategy on how to deal with emerging contaminants?

a list of usefull actions for identifying or confirming contaminants

20. Do you have specific questions about emerging contaminants in your country (like behaviour, route of exposure, occurrence, toxicity, remediation techniques, etc.)?

remidiation techniques for pesticedes and PFAS

21. What would you like to know from colleagues from other networks? (we will endeavour to provide this information in the questionnaire report).

- ☒ info about specific legislation
- ☐ info about policy
- ☒ info about remediation techniques and strategies
- ☒ info about environmental (soil / groundwater / sediment) investigation strategies
- ☐ info about scientific research

If so, please specify:

REFERENCES

Please give the most important references (leading literature, documents, website, projects, and case studies) that could be relevant for explaining your national approach on emerging contaminants or PFOS/PFOA.

<http://mst.dk/service/publikationer/publikationsarkiv/2013/apr/survey-of-pfos-pfoa-and-other-perfluoroalkyl-and-polyfluoroalkyl-substances---part-of-the-lous-review/>

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FINAL QUESTIONS

Do you have any questions or suggestions for the authors of this questionnaire?

please distribute ypur findings!

Are you interested in the establishment of a network focussing on emerging contaminants?

yes

Are you interested in being informed about developments around this questionnaire? Please provide your contact information (question 0).

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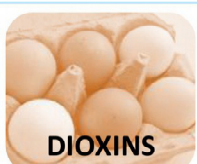
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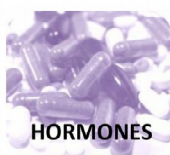
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DDT DDE DDD



NANO PARTICLES



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0. Fill in your country and function:

Country

Organisation:

Function

Expertise

Optional:

Telephone no.

Email

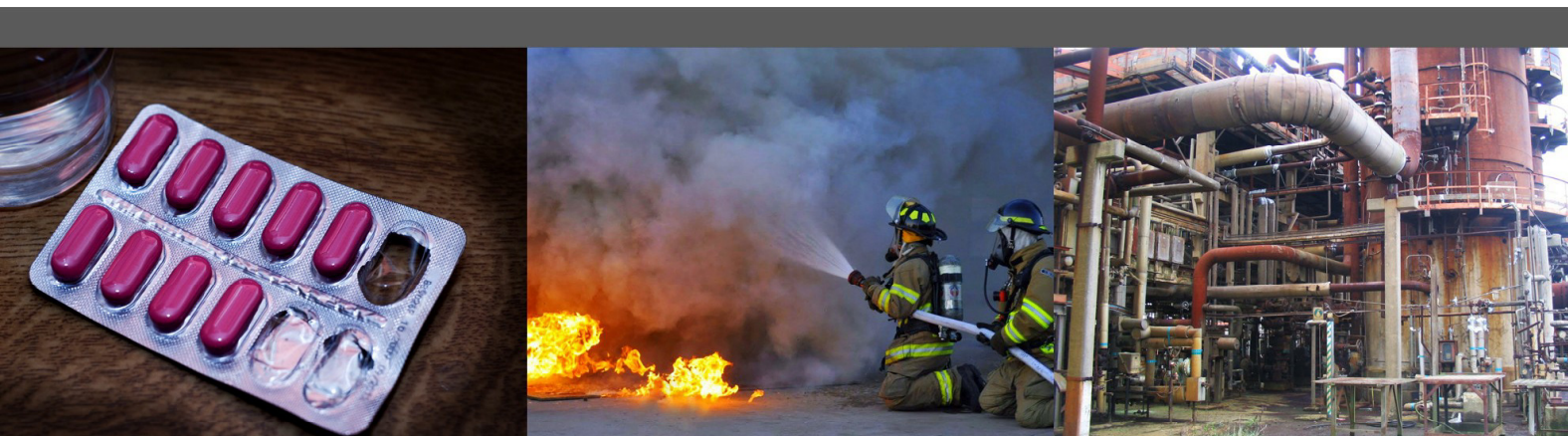
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AWARENESS

Definition by the United States Geological Survey:

“Any synthetic or naturally occurring chemical that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and(or) human health effects”.

1. Do you endorse the given definition of ‘emerging contaminants’?

- ☒ Yes, continue with question 2
- ☐ No, please give a better definition or comment on this definition:

The number of emerging contaminants is extensive. Therefore we further focus on one special group of emerging contaminants, the Persistent Organic Pollutants (POP). A number of Persistent Organic Pollutants are included in The Stockholm Convention on Persistent Organic Pollutants.

Stockholm Convention

This is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. In the Stockholm Convention chemicals targeted by the Convention are listed.

2. Please indicate which POP's from the Stockholm Convention you are familiar with in terms of contaminated land management/river basin management (soil, groundwater, sediments):

- ☐ Aldrin
- ☐ Bromo diphenylethers
- ☐ Chlordane
- ☐ Chlordecone
- ☐ HCB (Hexabromocyclohexane)
- ☐ Dieldrin
- ☐ Endrin
- ☐ Heptachlor
- ☐ Hexabromobiphenyl
- ☐ Hexabromodiphenyl ether and heptabromodiphenyl ether
- ☐ HCB (Hexachlorobenzene)
- ☐ Hexachlorobutadiene
- ☐ Alpha hexachlorocyclohexane
- ☐ Beta hexachlorocyclohexane

- ☐ Lindane (gamma hexachlorocyclohexane)
- ☐ Mirex
- ☐ Pentachlorobenzene
- ☐ PCB (Polychlorinated biphenyls)
- ☐ SCCPs (Short chain chlorinated paraffins)
- ☐ Technical endosulfan and its related isomers
- ☐ Tetrabromodiphenyl ether and pentabromodiphenyl ether
- ☐ Toxaphene
- ☐ DDT
- ☒ PFOS/PFOA (Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonfyl fluoride)
- ☐ PCP (Pentachlorophenol)
- ☐ PCDD (Polychlorinated dibenzo-p-dioxins)
- ☐ PCDF (Polychlorinated dibenzofurans)
- ☐ Polychlorinated naphthalenes.
- ☐ PeCB (Pentachlorobenzene)
- ☐ None

Persistent Organic Pollutants

Persistent organic pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. This group of priority pollutants consists of pesticides (such as DDT), industrial chemicals (such as polychlorinated biphenyls, PCBs) and unintentional by-products of industrial processes (such as dioxins and furans).

Persistent Organic Pollutants are transported across international boundaries far from their sources, even to regions where they have never been used or produced. The ecosystems and indigenous people of the Arctic are particularly at risk because of the long-range environmental transportation and bio-magnification of these substances. Consequently, persistent organic pollutants pose a threat to the environment and to human health all over the globe.

See more: <http://ec.europa.eu/environment/pops/>

3. Are there other emerging contaminants which are currently receiving attention in your country in relation to soil, groundwater and/or sediments (beside the substances in the list from the Stockholm Convention)?

If so, please write down which emerging contaminants these are. For example:

- ☐ Mineral oil
- ☐ Hormones
- ☐ Asbestos
- ☐ Heavy metals
- ☐ Chlorinated solvents
- ☐ MTBE
- ☐ Dioxanes
- ☐ Antibiotics
- ☐ Others, namely
- ☒ None

EMERGING CONTAMINANTS

Why are these emerging contaminants receiving your special attention?

What was the cause for this attention?

If documents are publicly available and relevant, you may upload these documents.

4. Please describe what kind of problems your country experiences with emerging contaminants in different environmental compartments (e.g. calamities, health problems, ecological problems) and write down what emerging contaminants it is about?

☐ In soil

What emerging contaminants?

Please typify the problem:

☒ In groundwater

What emerging contaminants?

PFOS/PFOA

Please typify the problem:

We found high concentrations in groundwater impacted by industrial activities. At the moment we do not relate the contamination to effects (health problems or

☐ In sediments

What emerging contaminants?

Please typify the problem:



Besides soil, groundwater and/or sediment related problems, is there attention for emerging contaminants in other environmental compartments?

☒ In drinking water What emerging contaminants?

PFOS/PFOA

Please typify the problem:

We found high concentrations in drinking water abstracted by groundwater impacted by industrial activities. At the moment we do not relate the

☒ In surface water What emerging contaminants?

PFOS/PFOA

Please typify the problem:

We found high concentrations in groundwater impacted by industrial activities. A preliminary field study was carried out to assess any impacts on a macrobenthic

☐ In atmosphere What emerging contaminants?

Please typify the problem:

☐ Other, being:

What emerging contaminants?

Please typify the problem:

☐ None, please continue to question 6

If documents are publicly available and relevant, you may upload these documents.

5. Which organisations in your country are dealing with emerging contaminants in the environment and why? (such as research institutes, NGOs, companies, universities, other governmental departments etc.). For example: which organization is responsible for research on emerging contaminants or which organisation has to deal with disasters/issues (e.g. big fires, flooding, spills)? Please write down the organisation and (if available) provide contact information of the relevant persons.

Organisation	Aim of the organisation	Contact information of relevant persons (name, adress, email, phone number)
Water Research Institu	Research Institution su	Stefano Polesello, Via Mulino 19, 20861 Brugherio MB. Italy polesello@irsa.cnr.it
National Health Institut	Nation's medical resear	Mario Carere, Viale Regina Elena 299, 00161 Rome, Italy mario.carere@iss.it
Institute for Environme	Technical Institute sup	Stefania Balzamo, Via di Castel Romano,100, 00128 Rome, Italy stefania.balzamo@icnrambiente.it



POLICY AND LEGISLATION

The following questions about policy and legislation are intended for governmental (related) organisations only. If this is not suitable for you or you do not work at such an organisation, please continue the questionnaire at question 9 (technical approach).

We are interested in the existing policy and legislation on emerging contaminants in the EU. We hereby focus on 'curative' policy and legislation, on how to deal with emerging contaminants which are already present in the environment. We explicitly exclude preventive policy, legislation and/or additional regulations (for example REACH).

6. 6A. Is there a policy or legislation on emerging contaminants in your country?

- ☐ In soil
- ☐ In groundwater
- ☐ In sediments

6B. Is there policy or legislation on emerging contaminants for other compartments, which are related to or has an interface with the compartments soil, groundwater and/or sediment?

- ☐ In food
- ☐ In agricultural products
- ☐ In drinking water
- ☐ In surface water
- ☐ In atmosphere
- ☐ Other, being

If so, please describe the relation/interface:

7. 7A. Policy: if there is policy on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions.

Please summarize the policy briefly:

What are the main policy objectives and characteristics?

What are the principles on which the national policy on emerging contaminants is based on (e.g. focus on hotspots, linking occurrence with potential sources, etc.)?

How is this policy implemented (is there legislation)?

What are in your opinion, the strengths and challenges with respect to the current policy in your country?

7B. If there is no such policy, please answer the following questions:

Do you know what's the reason why there is no policy (e.g. lack of urgency, available budget, etc.)?

Provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:

8. 8A. Legislation: If there is legislation on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions:

Summarize the legislation briefly:

What are the main legislation objectives and characteristics?

What are the principles on which the national legislation on emerging contaminants is based on?

How is this legislation implemented?

EMERGING CONTAMINANTS

What are in your opinion the strengths and challenges with respect to the current legislation in your country?

8B. If there is no such legislation, please answer the following questions:

Do you know the reason why there is no legislation (e.g. lack of urgency, available budget, etc.)?

Please provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:



TECHNICAL APPROACH

One of the problems with emerging contaminants is that they are not commonly and systematically measured. Therefore, it is often not known where and in what concentrations emerging contaminants occur.

9. Can you specify how you determine if emerging contaminants occur at a specific site or in a specific area?

10. Does your country/organisation have a list of parameters which are commonly analysed in soil, sediments and groundwater researches on (suspect) locations?

☐ If so, answer the following questions:

Please describe or upload which parameters are included on this list:

How was this list established (criteria/approach)?

Is there a procedure to add or delete parameters from this list?

Is one or more of the emerging contaminants listed in question 2 or 3 part of this list of commonly analysed parameters? If so, specify which:

- ☐ If not, how is decided which emerging contaminants must be analysed? Is this dependant on the specific site or area, or are other criteria decisive?

Investigation and analysis.

11. Is there a procedure or strategy (e.g. protocol, approach, methodology) for one or more emerging contaminants on how to investigate this in soil, sediments and/or groundwater?

- ☐ If so, please answer the questions below:

Describe this procedure:

How is this procedure established (what is it based on)?

Does this procedure apply for all emerging contaminants or for one or more specific emerging contaminants? Please describe for which emerging contaminants:

- ☐ If not, would you prefer to have a standard procedure or strategy for emerging contaminants in soil, sediments and/or groundwater? (why, and for which compounds?)

Remediation.

12. Once emerging contaminants are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. For which emerging contaminants do you know or use remediation techniques or approaches, or for which emerging contaminants do you feel the need to have this?

And which remediation techniques are used (e.g. isolation, capping, chemical oxidation, membrane technology)?

Monitoring data.

13. Which cases and/or monitoring data are available?

PFOS/PFOA AS AN EXAMPLE OF EMERGING CONTAMINANTS

PFOS and PFOA are on the Stockholm Convention list, and therefore at EU level recognized as emerging contaminants. In the Netherlands and Flanders, these parameters are considered as 'leading emerging contaminants', among others because of their occurrence in water treatment plants. However, in the Netherlands and in Flanders there is, despite of the societal relevance, no procedure on how to deal with these emerging contaminants. It is therefore important to learn more about these parameters, especially about their presence and behaviour in soil, groundwater and/or sediments. We are interested in suggestions on how to deal with PFOS and PFOA in soil, groundwater and sediments as an example of emerging contaminants. To explore the status of PFOS and PFOA in other EU countries, they are explored here in more detail.

PFOS/PFOA experts

If you know an expert on PFOS/PFOA in your network, we appreciate it if you let this expert also fill in the questions below.

14. Has your country been facing PFOS/PFOA in soil, sediments and/or groundwater?

☐ If not, go to question 17.

☒ If so, please answer the following questions:

What is your procedure when PFOS/PFOA is present in the environment?

Monitoring the spatial distribution and identification of sources. Comparing the measured concentrations to the Environmental Quality Standard derived in Italy for PFOA.

At which locations (landfill, fire station, airports, etc.) does it occur?

factory of fluoropolymers
factory of fluorochemicals
See attached files (IRSA_CommentsFinal.pdf and IRSA_CommentsTables.pdf) regarding IRSA General Comments to ECHA Public Consultation on PFOA and related articles.

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (e.g. landfill, fire station, airport)?

factory of fluoropolymers 3 µgPFOA/L (ground water)
factory of fluorochemicals 35 µgPFOA/L (ground water)

Specific sources PFOS/PFOA

15. Fire-fighting foam is a known source of PFOS/PFOA. Are you aware of calamities where fires were extinguished with a PFOS/PFOA containing foam? What was the procedure after this foam entered the environment? Has an investigation been performed? Which strategy was used?

We suspect that a aquifer has been contaminated by PFOS after using a PFOS containing foam to extinguish a fire. This source of PFOS has not been confirmed yet.

Other activities like de-icing, textile treatment or metal surface treatment can also cause PFOS/PFOA contamination. Do you have experience with these activities in relation to the occurrence of PFOS/PFOA?

We analyzed the discharge of WWTPs which receive most of the wastes from textile manufacturers. The concentration in the effluents of these WWTPs were much higher than

Remediation of PFOS/PFOA.

16. Once PFOS/PFOA are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. Do you know of any remediation techniques or approaches for PFOS/PFOA? And which remediation techniques are used for PFOS/PFOA (e.g. isolation, capping, chemical oxidation, membrane technology)?

Contaminated ground waters are treated with vegetal charcoal in order to remove perfluorinated in drinking waters.

Surface water and drinking water.

17. Has your country been facing PFOS/PFOA in surface water and/or drinking water?

☐ If not, go to question 18.

☒ If so, please answer the following questions:

At which locations (water treatment plants, sewage discharge points, etc.) does it occur?

factory of fluoropolymers
factory of fluorochemicals
textile district
industrial areas

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (water treatment plants, sewage discharge points, etc.) ?

factory of fluoropolymers 6.5 µgPFOA/L (surface water downstream industrial discharge)
factory of fluorochemicals 3 µgPFOA/L surface water downstream industrial discharge)
textile district 222 µgPFOA/L (surface water downstream industrial discharge)

SUGGESTIONS FOR FOLLOW-UP

18. Would you find a (national or European) strategy or approach on how to deal with emerging contaminants helpful?

19. What information do you need to develop a strategy on how to deal with emerging contaminants?

20. Do you have specific questions about emerging contaminants in your country (like behaviour, route of exposure, occurrence, toxicity, remediation techniques, etc.)?

21. What would you like to know from colleagues from other networks? (we will endeavour to provide this information in the questionnaire report).

- ☒ info about specific legislation
- ☒ info about policy
- ☒ info about remediation techniques and strategies
- ☒ info about environmental (soil / groundwater / sediment) investigation strategies
- ☒ info about scientific research

If so, please specify:

REFERENCES

Please give the most important references (leading literature, documents, website, projects, and case studies) that could be relevant for explaining your national approach on emerging contaminants or PFOS/PFOA.

IRSA_CommentsFinal.pdf
IRSA_CommentsTables.pdf
2015_Valsecchi_Chemosphere_PFAS_Abstract.pdf

Documents, links or other information, which may be useful in this survey, can be uploaded to the following e-mail address: info@emergingcontaminants.eu

FINAL QUESTIONS

Do you have any questions or suggestions for the authors of this questionnaire?

Are you interested in the establishment of a network focussing on emerging contaminants?

Are you interested in being informed about developments around this questionnaire? Please provide your contact information (question 0).

For more information or questions regarding this questionnaire you can send an email to info@emergingcontaminants.eu. Or you can contact us at phone number +31 570-665878 (Arne Alphenaar, TTE, the Netherlands) or +31 570-697184 (Martijn van Houten, Witteveen+Bos, the Netherlands).



Questionnaire on Contaminated Land Management in Europe

Emerging contaminants

AIM OF THIS QUESTIONNAIRE

With increasing frequency countries and organisations are faced with chemicals that have not been considered as 'contaminants' before. Some of these chemicals could be a potential risk to humans and/or the environment. These are the so-called 'emerging contaminants'. Roughly defined by the United States Geological Survey as "any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects".

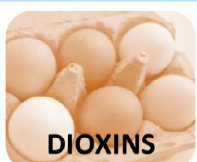
Characteristic for emerging contaminants is that too little is known about the occurrence, the actual risks and the approach to formulate appropriate policy and legislation. To properly identify how to deal with emerging contaminants knowledge, awareness and understanding is necessary.

Commissioned by the Ministry of I&M / RWS (Netherlands) and the OVAM (Flanders), this questionnaire has been developed. This questionnaire aims to wrap up available knowledge and experience related to legislation, governance and policy. The focus is on the presence and the curative policy on emerging contaminants that are already present in the soil, groundwater and sediments.

This questionnaire is a first step to decide whether it is necessary to develop an effective approach on how to deal with emerging contaminants. The results of this inventory will be shared and discussed. Based on this discussion a decision is made whether the development of a strategy on how to deal with emerging contaminants is necessary.

APPROACH

The group of emerging contaminants is very diverse in terms of toxicity, behaviour, remediation/treatment technique and so forth. As a consequence, the dimensions of the problem are not clear. Also the current knowledge and especially the actual approaches on how to deal with emerging contaminants in different countries are not well known.



DDT DDE DDD



PFOS



NANO PARTICLES



Characteristics of emerging contaminants

The various emerging contaminants have in common that there is much uncertainty about them, which leads to the absence of a strategy and policy. The following observations about emerging contaminants are:

- More than 2100 scientific studies have shown that they pose a potential risk to humans, plants and / or animals. However, there's a lack of knowledge of the practical implications;
- The emerging contaminants are not examined in regular environmental investigation. This leads to a lack of data;
- As a result of a lack of data, little is known about the practical situation and risks in the soil, sediment and groundwater system;
- Appropriate strategies and technologies to control existing contaminants are not in development;
- Uncertainty about legal and financial consequences of (potential) contamination will hamper an efficient approach.

This questionnaire aims at the policy and legislation in the European Union, related to man-made emerging contaminants that already are present in the environment in the compartments soil, groundwater and sediment. It is not about preventive legislation (REACH), nor about the application of emerging contaminants.

Therefore we distinguish the following themes in the questionnaire:

- Awareness of emerging contaminants (questions 1 - 5);
- Policy and legislation related to emerging contaminants (questions 6 - 8);
- Technical approach (questions 9 - 13);
- Focus on PFOS and PFOA as a 'pilot' emerging contaminants (questions 14 - 17);
- Suggestions for follow-up (questions 18 - 21).

PROCESS AND RESULTS

The questionnaire is spread among the members of the Common Forum and. Also members of the related network organisations SedNet and NICOLE, which are also participating in the Common Forum, are asked to fill in this questionnaire.

For this inventory we developed a website (www.emergingcontamints.eu) and this questionnaire. The website can be used to upload relevant documents that may be used and shared publicly.

Please feel free to send the web-link or this form to colleagues or related organisations if you think that they can give valuable information. It is also possible that not all questions can be answered. Please skip those questions or contact a colleague for those questions! The form can be saved and edited or filled later on.

Participants will be informed about the results of the questionnaire. Results of this questionnaire will be treated anonymously. Information such as name, function and organisation is not necessary, but might be helpful for us to interpret the results.

EMERGING CONTAMINANTS

It is possible that you cannot answer all questions. Please skip those questions and continue the questionnaire. You can also send this form to a colleague. The form can be saved and edited or filled later on.

0. Fill in your country and function:

Country

Organisation:

Function

Expertise

Optional:

Telephone no.

Email

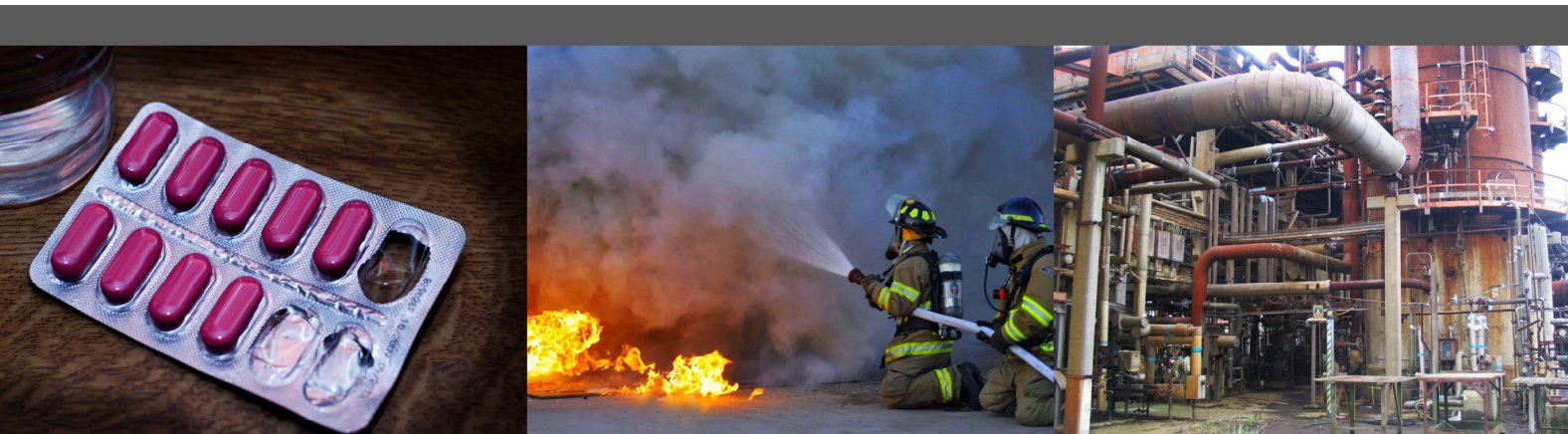
Unless you tick the next boxes, answers will be treated strictly anonymously.

- ☒ I have no objection that my answers will be related in a report to me.
- ☐ I have no objection that my answers will be related in a report to my organization.
- ☐ I have no objection when the documents I upload will be related in a report to me or my organization.
- ☐ I have no objection when the documents I upload will be accessible to other people via a website.

Documents, links or other information, which may be useful in this survey, can be sent to the following e-mail address:

Info@emergingcontaminants.eu

Also questions regarding this questionnaire can be sent to info@emergingcontaminants.eu. You can also contact us at phone number +31 570-665878 (Arne Alphenaar, TTE) or +31 570-697184 (Martijn van Houten, Witteveen+Bos).



AWARENESS

Definition by the United States Geological Survey:

“Any synthetic or naturally occurring chemical that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and(or) human health effects”.

1. Do you endorse the given definition of ‘emerging contaminants’?

- ☒ Yes, continue with question 2
- ☐ No, please give a better definition or comment on this definition:

The number of emerging contaminants is extensive. Therefore we further focus on one special group of emerging contaminants, the Persistent Organic Pollutants (POP). A number of Persistent Organic Pollutants are included in The Stockholm Convention on Persistent Organic Pollutants.

Stockholm Convention

This is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. In the Stockholm Convention chemicals targeted by the Convention are listed.

2. Please indicate which POP's from the Stockholm Convention you are familiar with in terms of contaminated land management/river basin management (soil, groundwater, sediments):

- ☒ Aldrin
- ☐ Bromo diphenylethers
- ☒ Chlordane
- ☐ Chlordecone
- ☐ HCB (Hexachlorobenzene)
- ☐ Dicofo
- ☒ Dieldrin
- ☒ Endrin
- ☒ Heptachlor
- ☐ Hexabromobiphenyl
- ☐ Hexabromodiphenyl ether and heptabromodiphenyl ether
- ☐ HCB (Hexachlorobenzene)
- ☐ Hexachlorobutadiene
- ☐ Alpha hexachlorocyclohexane
- ☐ Beta hexachlorocyclohexane

- ☒ Lindane (gamma hexachlorocyclohexane)
- ☐ Mirex
- ☐ Pentachlorobenzene
- ☒ PCB (Polychlorinated biphenyls)
- ☐ SCCPs (Short chain chlorinated paraffins)
- ☐ Technical endosulfan and its related isomers
- ☐ Tetrabromodiphenyl ether and pentabromodiphenyl ether
- ☐ Toxaphene
- ☒ DDT
- ☒ PFOS/PFOA (Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonfyl fluoride)
- ☒ PCP (Pentachlorophenol)
- ☐ PCDD (Polychlorinated dibenzo-p-dioxins)
- ☐ PCDF (Polychlorinated dibenzofurans)
- ☐ Polychlorinated naphthalenes.
- ☐ PeCB (Pentachlorobenzene)
- ☐ None

Persistent Organic Pollutants

Persistent organic pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. This group of priority pollutants consists of pesticides (such as DDT), industrial chemicals (such as polychlorinated biphenyls, PCBs) and unintentional by-products of industrial processes (such as dioxins and furans).

Persistent Organic Pollutants are transported across international boundaries far from their sources, even to regions where they have never been used or produced. The ecosystems and indigenous people of the Arctic are particularly at risk because of the long-range environmental transportation and bio-magnification of these substances. Consequently, persistent organic pollutants pose a threat to the environment and to human health all over the globe.

See more: <http://ec.europa.eu/environment/pops/>

3. Are there other emerging contaminants which are currently receiving attention in your country in relation to soil, groundwater and/or sediments (beside the substances in the list from the Stockholm Convention)?

If so, please write down which emerging contaminants these are. For example:

- ☐ Mineral oil
- ☐ Hormones
- ☐ Asbestos
- ☐ Heavy metals
- ☒ Chlorinated solvents
- ☒ MTBE
- ☒ Dioxanes
- ☐ Antibiotics
- ☐ Others, namely
- ☐ None

1,2,3-trichloropropane

EMERGING CONTAMINANTS

Why are these emerging contaminants receiving your special attention?

regulatory interest

What was the cause for this attention?

groundwater or drinking water impacts

If documents are publicly available and relevant, you may upload these documents.

4. Please describe what kind of problems your country experiences with emerging contaminants in different environmental compartments (e.g. calamities, health problems, ecological problems) and write down what emerging contaminants it is about?

☒ In soil

What emerging contaminants?

pesticides

Please typify the problem:

site-specific storage and accidental release prior to use, or disposal

☒ In groundwater

What emerging contaminants?

PFOA/PFOS, dioxane, MTBE

Please typify the problem:

Impacts to groundwater from historical usage and release

☐ In sediments

What emerging contaminants?

Please typify the problem:



Besides soil, groundwater and/or sediment related problems, is there attention for emerging contaminants in other environmental compartments?

☒ In drinking water What emerging contaminants?

dioxane and PFCs

Please typify the problem:

drinking water supplies impacted, as identified in EPA UCMR# sampling

☐ In surface water What emerging contaminants?

Please typify the problem:

☐ In atmosphere What emerging contaminants?

Please typify the problem:

☐ Other, being:

What emerging contaminants?

Please typify the problem:

☐ None, please continue to question 6

If documents are publicly available and relevant, you may upload these documents.

5. Which organisations in your country are dealing with emerging contaminants in the environment and why? (such as research institutes, NGOs, companies, universities, other governmental departments etc.). For example: which organization is responsible for research on emerging contaminants or which organisation has to deal with disasters/issues (e.g. big fires, flooding, spills)? Please write down the organisation and (if available) provide contact information of the relevant persons.

Organisation	Aim of the organisation	Contact information of relevant persons (name, adress, email, phone number)
US EPA	Protect the environmei	
US Air Force	Reduce their liability	Janet Anderson



POLICY AND LEGISLATION

The following questions about policy and legislation are intended for governmental (related) organisations only. If this is not suitable for you or you do not work at such an organisation, please continue the questionnaire at question 9 (technical approach).

We are interested in the existing policy and legislation on emerging contaminants in the EU. We hereby focus on 'curative' policy and legislation, on how to deal with emerging contaminants which are already present in the environment. We explicitly exclude preventive policy, legislation and/or additional regulations (for example REACH).

6. 6A. Is there a policy or legislation on emerging contaminants in your country?

- ☐ In soil
- ☒ In groundwater
- ☐ In sediments

6B. Is there policy or legislation on emerging contaminants for other compartments, which are related to or has an interface with the compartments soil, groundwater and/or sediment?

- ☐ In food
- ☐ In agricultural products
- ☒ In drinking water
- ☐ In surface water
- ☐ In atmosphere
- ☐ Other, being

If so, please describe the relation/interface:

drinking water well impacts lead to groundwater investigations

7. 7A. Policy: if there is policy on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions.

Please summarize the policy briefly:

provisional health advisories from US EPA drive facility owners to sample. Unregulated Contaminant Monitoring Rule 3 identified impacts to Drinking water that are subsequently investigated and polluters found.

What are the main policy objectives and characteristics?

reduce human health exposures

What are the principles on which the national policy on emerging contaminants is based on (e.g. focus on hotspots, linking occurrence with potential sources, etc.)?

drinking water occurrences

How is this policy implemented (is there legislation)?

yes, UCMR3 is required under the Safe Drinking Water Act.

What are in your opinion, the strengths and challenges with respect to the current policy in your country?

Focus on drinking water is good, identifies many unknown sources.

7B. If there is no such policy, please answer the following questions:

Do you know what's the reason why there is no policy (e.g. lack of urgency, available budget, etc.)?

Provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:

8. 8A. Legislation: If there is legislation on emerging contaminants in soil, sediments and/or groundwater in your country, please answer the following questions:

Summarize the legislation briefly:

What are the main legislation objectives and characteristics?

What are the principles on which the national legislation on emerging contaminants is based on?

How is this legislation implemented?

EMERGING CONTAMINANTS

What are in your opinion the strengths and challenges with respect to the current legislation in your country?

8B. If there is no such legislation, please answer the following questions:

Do you know the reason why there is no legislation (e.g. lack of urgency, available budget, etc.)?

lack of sound science behind many emerging contaminants health criteria, push back from industry.

Please provide your thoughts on how to tackle the problem of emerging contaminants in soil, sediments and/or groundwater:



TECHNICAL APPROACH

One of the problems with emerging contaminants is that they are not commonly and systematically measured. Therefore, it is often not known where and in what concentrations emerging contaminants occur.

9. Can you specify how you determine if emerging contaminants occur at a specific site or in a specific area?

Historical site usage and co-contaminants are key indicators of probability of occurrence.

10. Does your country/organisation have a list of parameters which are commonly analysed in soil, sediments and groundwater researches on (suspect) locations?

☐ If so, answer the following questions:

Please describe or upload which parameters are included on this list:

The only comprehensive list is the US EPA RCRA Appendix IX list:
<http://www.gpo.gov/fdsys/pkg/CFR-2011-title40-vol26/pdf/CFR-2011-title40-vol26-part264-appIX.pdf>

How was this list established (criteria/approach)?

Title 40 - Protection of Environment
Chapter I - ENVIRONMENTAL PROTECTION AGENCY (CONTINUED)
Subchapter I - SOLID WASTES (CONTINUED)
Part 264 - STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE

Is there a procedure to add or delete parameters from this list?

Not that I know of. Has not been changed since 2005.

Is one or more of the emerging contaminants listed in question 2 or 3 part of this list of commonly analysed parameters? If so, specify which:

Pesticides, PCBs, PCP, DDT, etc.

- ☒ If not, how is decided which emerging contaminants must be analysed? Is this dependant on the specific site or area, or are other criteria decisive?

Local regulatory interest, site history, local community pressure, UCMR3 results form nearby wells.

Investigation and analysis.

11. Is there a procedure or strategy (e.g. protocol, approach, methodology) for one or more emerging contaminants on how to investigate this in soil, sediments and/or groundwater?

- ☐ If so, please answer the questions below:

Describe this procedure:

How is this procedure established (what is it based on)?

Does this procedure apply for all emerging contaminants or for one or more specific emerging contaminants? Please describe for which emerging contaminants:

- ☒ If not, would you prefer to have a standard procedure or strategy for emerging contaminants in soil, sediments and/or groundwater? (why, and for which compounds?)

Perhaps a SOP for PFCs to avoid sampling interferences from the use of polytetrafluoroethene (e.g., Teflon, Viton) in sampling materials.

Remediation.

12. Once emerging contaminants are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. For which emerging contaminants do you know or use remediation techniques or approaches, or for which emerging contaminants do you feel the need to have this?

1,4-dioxane has remedies. Pesticides and herbicides and PCBs are established for soils.

And which remediation techniques are used (e.g. isolation, capping, chemical oxidation, membrane technology)?

DX - Advanced oxidation, emerging biodegradation. For pest/PCBs - dig and haul is acceptable.

Monitoring data.

13. Which cases and/or monitoring data are available?

PFOS/PFOA AS AN EXAMPLE OF EMERGING CONTAMINANTS

PFOS and PFOA are on the Stockholm Convention list, and therefore at EU level recognized as emerging contaminants. In the Netherlands and Flanders, these parameters are considered as 'leading emerging contaminants', among others because of their occurrence in water treatment plants. However, in the Netherlands and in Flanders there is, despite of the societal relevance, no procedure on how to deal with these emerging contaminants. It is therefore important to learn more about these parameters, especially about their presence and behaviour in soil, groundwater and/or sediments. We are interested in suggestions on how to deal with PFOS and PFOA in soil, groundwater and sediments as an example of emerging contaminants. To explore the status of PFOS and PFOA in other EU countries, they are explored here in more detail.

PFOS/PFOA experts

If you know an expert on PFOS/PFOA in your network, we appreciate it if you let this expert also fill in the questions below.

14. Has your country been facing PFOS/PFOA in soil, sediments and/or groundwater?

☐ If not, go to question 17.

☒ If so, please answer the following questions:

What is your procedure when PFOS/PFOA is present in the environment?

sample. postpone remediation until a cost-effective remedy is found.

At which locations (landfill, fire station, airports, etc.) does it occur?

fire training areas, hangars, crash sites, fire stations, airports.

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (e.g. landfill, fire station, airport)?

See UCMR3 data in drinking water
(<http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/data.cfm#ucmr2013>) and
Cornell Long, 2015 presentation of USAF findings from REMTECH in Westminster
Colorado

Specific sources PFOS/PFOA

15. Fire-fighting foam is a known source of PFOS/PFOA. Are you aware of calamities where fires were extinguished with a PFOS/PFOA containing foam? What was the procedure after this foam entered the environment? Has an investigation been performed? Which strategy was used?

I am aware of several, most have not been investigated.

Other activities like de-icing, textile treatment or metal surface treatment can also cause PFOS/PFOA contamination. Do you have experience with these activities in relation to the occurrence of PFOS/PFOA?

minimally.

Remediation of PFOS/PFOA.

16. Once PFOS/PFOA are measured in soil, groundwater or sediment, treatment, containment or remediation strategies come into view. Do you know of any remediation techniques or approaches for PFOS/PFOA? And which remediation techniques are used for PFOS/PFOA (e.g. isolation, capping, chemical oxidation, membrane technology)?

Remediation techniques are limited and of variable effectiveness. Oxidation, reduction, fungal and microbial degradation are all questionable. Sorption techniques are demonstrated on PFOS and PFOA but not precursors. In my opinion, at present, there are no acceptable low cost or in situ remedial technologies suitable for all PFCs.

Surface water and drinking water.

17. Has your country been facing PFOS/PFOA in surface water and/or drinking water?

☐ If not, go to question 18.

☒ If so, please answer the following questions:

At which locations (water treatment plants, sewage discharge points, etc.) does it occur?

water supplies have been sampled, 0.8% had detections. See UCMR3 link above.

Is monitoring data on PFOS/PFOA available? If so, which maximum concentrations are measured at which type of locations (water treatment plants, sewage discharge points, etc.) ?

<http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/data.cfm#ucmr2013>

SUGGESTIONS FOR FOLLOW-UP

18. Would you find a (national or European) strategy or approach on how to deal with emerging contaminants helpful?

Yes. Reduces uncertainty.

19. What information do you need to develop a strategy on how to deal with emerging contaminants?

20. Do you have specific questions about emerging contaminants in your country (like behaviour, route of exposure, occurrence, toxicity, remediation techniques, etc.)?

21. What would you like to know from colleagues from other networks? (we will endeavour to provide this information in the questionnaire report).

- ☐ info about specific legislation
- ☐ info about policy
- ☒ info about remediation techniques and strategies
- ☒ info about environmental (soil / groundwater / sediment) investigation strategies
- ☐ info about scientific research

If so, please specify:

REFERENCES

Please give the most important references (leading literature, documents, website, projects, and case studies) that could be relevant for explaining your national approach on emerging contaminants or PFOS/PFOA.

Washington Works C8 site in West Virginia, 3M sites in Minnesota, USAF former Wurtsmith AFB, Air National Guard Newark Delaware,

Documents, links or other information, which may be useful in this survey, can be uploaded to the following e-mail address: info@emergingcontaminants.eu

FINAL QUESTIONS

Do you have any questions or suggestions for the authors of this questionnaire?

Are you interested in the establishment of a network focussing on emerging contaminants?

Perhaps., although as a US-based scientist, I doubt I'd be able to be involved in Europe.

Are you interested in being informed about developments around this questionnaire? Please provide your contact information (question 0).

For more information or questions regarding this questionnaire you can send an email to info@emergingcontaminants.eu. Or you can contact us at phone number +31 570-665878 (Arne Alphenaar, TTE, the Netherlands) or +31 570-697184 (Martijn van Houten, Witteveen+Bos, the Netherlands).



III

APPENDIX: FACT SHEETS ON PFOS AND PFOA

Introduction

The establishment of the Centre of Expertise for PFOS was an initiative taken by Witteveen + Bos and TTE Consultants. The reason for this initiative were signals given by the soil market that PFOS (and its related compounds) could well be or become an environmental issue. Specific questions from market parties showed this category of substances to be challenging from the perspective of technical investigation and remediation as well as at policy and legal levels.

There is a need to know about and get an insight into PFOS and related emerging contaminants in order to handle them. To achieve this we have taken the initiative to establish the Centre of Expertise for PFOS.

It is our aim to make this centre a place where stakeholders on the ground can share their knowledge and judgments. But also a place to support initiatives to gain an insight and develop skills. As such the Centre of Expertise is an experiment that allows us to tackle PFOS and other emerging contaminants together with market parties, governments and research institutions.

We will stimulate a collective approach for the development of the Centre for Expertise and we will allow this creation at least two years to develop and grow. Ideas and initiatives are shared on the website www.expertisecentrumPFOS.nl and through meetings.

Although there are still quite a few questions, we also have a considerable amount of information about PFOS and we appreciate the efforts made by all producers. We have disclosed the information available in a number of fact sheets (version 1).

The following fact sheets are available:

- PFOS and PFOA - introduction into the properties (English and Dutch version)
- Manufacturing - use - sources (English and Dutch version)
- Developments and policy - Netherlands (Dutch version only)
- Developments and policy - International (English and Dutch version)
- Source - Path - Property (Dutch version only)
- Toxicology (English and Dutch version)
- Behaviour in soil and water (English and Dutch version)
- Remediation technology (Dutch version only)
- Bibliography

We would like to invite parties to complement these factsheets and improve the contents where desired. Updated versions will be made available via the website.

Production - use - sources

Production and Applications

The most common processes for the production of fluorinated chemicals are electrochemical fluorination (ECF) and telomerisation. Telomerisation is a process in which iodic pentafluoroethane reacts with tetrafluoroethylene and ethylene to produce a polyfluoroalkane. 3M used to produce PFOS by electrochemical fluorination and was the world's largest producer of PFOS in the period from 1949 to 2002. Production sites were situated in the USA (Decatur, Alabama) and Belgium (Zwijndrecht near Antwerp). Also Miteni (Northern Italy) produced PFAS (Per Fluor Alkylated Substances) by means of ECF. Other manufacturers, including DuPont, Daikin, Clariant, Asahi Glass, Atofina, used the telomerisation process for the production of PFAS. In 2000 EPA discussed PFAS production in the United States, Italy, Germany, Japan and the Soviet Union. Annual production of PFOS derivatives (POSF) in 2000 was estimated at 4650 tons. PFAS is currently still being produced in Germany, Italy and at fifteen locations in China.

The main applications of PFOS are or were:

- additive in fire-fighting foam (AFFF). This has been prohibited since June 27 2011. AFFF extinguishing foams have been actively replaced by PFOS-free extinguishing foams
- mist suppressant and humectant in plating processes
- providing grease, oil and water resistance to various industrial and consumer applications, such as carpets, paper and cardboard (also for food packaging applications), textiles and leather, carpet cleaner, insecticides, 'sticky notes' and non-stick pans (PTFE). Examples of well-known brands are Scotchgard™, Zonyl, Baygard, Tefal, Post-it, et cetera. These are applications of PFOS-monomers as well as polymers
- surfactants for mining and oil extraction
- currently approved applications in which limited quantities of PFAS are used: photo lithography (etching patterns on computer chips), photographic coatings and hydraulic fluids for aviation.

It must be noted that all fluorochemical product, including the polymers, always contain a small quantity of residues, starting material or intermediate product which has not or has partly reacted. Common residues include PFOS and PFOA, or substances that will be eventually converted into PFOS or PFOA.

Application	Explanation	Estimated amount Use / emissions (tonnes per year)
Carpet Industry (i) (Polymers)	Surface treatment dirt and water repellent	15/10
Paper and cardboard (Phosphates)	Import and no production of greaseproof paper and similar products	60-105 (ii) / not known
Textile Industry (Polymers)	Surface treatment, dirt and water repellent: e.g. tablecloths, upholstery, rainwear, bedding	not known / 100% (2-3% of the textile)
Leather (Polymers)	Surface treatment, water repellent	10-20 /
Fire fighting foam (Monomers)		1.13 to 3.81 / 1.13 to 3.81
Specialty surfactants (Monomers)	e.g. mist suppressant in chromium plating, chips and aviation fluids	not known
Polymerization help (Monomers)		> 1 / > 0.77

Explanation table (2002 data):

(i) The textile industry in the Netherlands consists of many small and medium sized enterprises, some of which make use of fluorosurfactants. Note: In the UK carpet and textile industries are responsible for about 50% of the national use of PFCs.

(ii) Greaseproof paper is mainly imported from Germany and Scandinavia, and it is estimated that 60-105 tons of fluoroalkyl phosphate are imported with it. Note: Not available, emissions will occur during recycling and incineration / landfilling.

(iii) In the Netherlands there is one production plant for fluoropolymers that uses more than one tonne of PFOA per year.

Emissions

- during production
- during use
- released by waste after use (both collected and not collected waste, monomers and polymers)

- waste treatment (incineration, waste water treatment)
- Indirect emissions: chemical impurity during production POSF, or by degradation of POSF derivatives into PFOS in the environment

Possible sources of soil and (ground) water contamination

- production, discharges and emissions
- storing extinguishing foams
- use of extinguishing foams (practice locations and fires)
- metalworking industry (chrome plating)
- carpet and textile industry (surface treatment)
- water treatment plants
- landfills.

PFOS and PFOA

Introduction into the properties

PFOS and PFOA are the best known perfluorinated (fully fluorinated) organics. These substances are chemically very inert, resistant to high temperatures, they reduce surface tension and are water and dirt repellent and grease proof. Due to their properties, these materials are widely used in surface treatments of carpets, textiles, leather, paper and cardboard, but also as a surfactant in extinguishing foams, mist suppressant in chrome plating and as a surfactant in the mining and oil industries. The very properties that have made these materials into an industrial success, also lead to persistency, bio-accumulation and, in some cases, their toxicity in the environment. The following table summarizes PFOS and PFOA properties.

Abbreviation	Name and CAS number	Structural formula
PFOS	perfluorooctane sulfonic acid 1763-23-1 in dissociated form called Perfluorooctane sulfonate	$C_8F_{17}SO_3H$ Derivatives according to Stockholm Convention: K, Li, NH_4^+ -, DEA, TEA and DD-DMA salts and PFOSF
PFOA	Perfluorooctanoic 335-67-1	$C_7F_{15}CO_2H$

Variants

In addition to PFOS and PFOA there are many variants with longer or shorter carbon chains or polymers which have been frequently used. Perfluorinated compounds are also referred to as PFAS (Per Fluoro alkylated Substances) or PFC (Per Fluoro Chemicals). PFAS concentrations found in environmental research are often dominated by PFOS and PFOA.

Legislation (e.g. the Stockholm Convention and EU regulations) uses the term PFOS whenever perfluorooctane sulfonic acids are meant, also known as PFOS and PFOS derivatives, often precursors of PFOS.

Why is PFOS a problem?

The substance is very stable, even at high temperatures. It is this quality that makes PFOS a perfect fire-fighting foam. Complete combustion of PFOS requires a combustion temperature of at least 1.100 °C. PFOS has been found worldwide in birds, fish and other fauna, even on the North Pole. In the Netherlands, the substance is found in very low concentrations in drinking water.

Studies show that the substance accumulates in the food chain and that the average residence time in the human body amounts to 5.4 years. For PFOA the average residence time is 4 years.

	PFOS	PFOA
Molar mass (g / mol)	500.1	414.1
Solubility (mg / l)	370	9500
pKa	-3.27 (strong acid, calculated value)	0 - 3.8 (variation in reported pKa values)
Vapour pressure (Pa)	$3,31 \cdot 10^{-4}$	$1,3 \cdot 10^{-3}$
Log Kow	Formation of three phases	cannot be determined
Log Koc	(4.2 #)	(3.7 #)
Melting point	≥ 400 °C	45-50 °C
Boiling point	cannot be determined	188 °C
Henry's Law Constant ($atm \cdot m^3/mol$)	$4,34 \cdot 10^{-7}$	cannot be determined
Tolerable Daily Intake (TDI, ng / kg body weight)	150	1500
MTR (surface water, ng / L)	0.65	not derived
Provisional restoration value land $\mu g / kg$	0.1 to 100	not prepared
Provisional restoration value groundwater remediation g / l	0.010 to 4.7	not prepared

Large variations, see the fact sheet 'Behaviour in soil and water'

The main producer of PFOS (3M) has phased out the production of PFOS on a voluntary basis in 2002. In 2006 the European Union proclaimed a ban on the production, trade and use of PFOS and in 2009 PFOS was included in the Stockholm Convention. In 2011, the RIVM has conducted a preliminary investigation into the recovery values in soil and groundwater and in April 2013 PFOS was listed in the Water Framework Directive.

The substance is toxic, it accumulates in the liver and in the blood and it can easily cross the placenta. The mechanism of toxicity is not fully clear. Experiments with animals showed liver toxicity, effects on biochemical parameters related to lipid metabolism, reproductive toxicity and immunological effects.

Developments and policy

International

Worldwide, the behaviour of PFOS, PFOA and other perfluorinated chemicals has been closely monitored for quite some time and environmental effects are being investigated. This has led to several international developments and international policy.

United States and Canada

The largest producer of PFOS was 3M, a US company with manufacturing facilities in the United States and Belgium. PFOS was produced in the period from 1949 to 2002. Since the 70s the possible health effects due to occupational exposure to PFOS and PFOA have been monitored.

In 1993 concentrations of PFOA in the blood of both employees of a PFOA plant and the population of the region led to a scientific study into a possible link between the concentration in the blood and mortality rates. The first scientific publication showing the presence of PFOS and PFOA in the global environment dates back to 2001. In consultation with the EPA 3M's production of PFOS completely phased out in the period 2000-2002.

The EPA has also established contacts with other chemical companies and foreign governments. The goal was to phase out the production of PFOS and PFOS-related chemicals voluntarily. In practice, this has led to an agreement between the EPA and eight leading global companies focused on the emission and eventually eliminating PFOA and PFOA-related chemicals by 2015.

In 2006 Canada decided to include PFOS and PFOS derivatives in their environmental legislation, Schedule 1 under the Canadian Environmental Protection Act (lit. 101). PFOA and PFOA derivatives are scheduled to be included in the Canadian Environmental Protection Act.

European Union

Within the European Union PFOS is considered persistent, bioaccumulative and toxic (PBT). Since December 2006, the use of PFOS (and PFOS derivatives) for most applications has been severely limited.

PFOS may still be used in products in the following five cases:

- in certain photolithography processes (for the production of chips)
- photographic coatings applied to films, papers, or printing plates
- mist suppressants in the electroplating industry
- hydraulic fluids for aviation
- fire-fighting foams (allowed until June 27, 2011).

The use of PFOS in these five applications will be phased out as soon as safer alternatives are technically and economically feasible.

PFOA and its salts are likely to have a similar risk profile as PFOS. This is why the European Union is closely following the on-going risk assessment activities and the availability of safer alternatives. When safer alternatives become available, the marketing and use of PFOA will be restricted.

In the Netherlands since June 22, 2009, these limitations are regulated via the REACH Regulation (Registration, Evaluation, Authorisation and Restriction of Chemicals). In 2010 PFOS was included in the revised version of the European POP Regulation. As a result, the inclusion was left out of the REACH Regulation in the course of 2011.

On April 17, 2013 PFOS and PFOS-related substances were listed as a priority substance in the Water Framework Directive. In 2027 Member States will have to meet the standards derived for these substances.

Stockholm Convention

In 2002 The Netherlands became a party to the Stockholm Convention. This Convention entered into force on 17 May 2004. It has defined a binding global ban on the production of and trade in twelve POPs.

POP stands for Persistent Organic Pollutants. These are toxic, poorly degradable and may also be spread over a long distance through the air and / or water. POPs are harmful to the environment and health as they accumulate in organisms. This may lead to health effects such as cancer, reproduction damage and impairment of the immune system.

In 2009 the Fourth Conference of Parties (COP 4, May 2009) agreed to add nine new substances to the Stockholm Convention, including PFOS and PFOS derivatives.

Based on the Stockholm Convention, a National Implementation Plan (NIP) and a National Action Plan (NAP) have to be devised, including a review of the national situation and the measures that have been taken and will be taken to comply with the Treaty.

The Dutch Implementation Plan indicates that due to the persistent properties the chances are very high that many POPs will still be found in soil and water. It also indicates that POPs may be released again from contaminated compartments and contribute to a certain degree of human exposure through water, soil and food.

This means that the production, use, (re) sale and import of PFOS and PFOS-containing products is prohibited. Canada has made exceptions similar to those of the European Union.

As far as is known, there have never been any production sites of PFOS in the Netherlands. However the Netherlands have imported PFOS for a long time for various industrial uses. Also PFOA has been polymerized in the Netherlands. Environmental standards for PFOS in fresh water, drinking water and sea water have been proposed but they have not yet been officially established.

Toxicology

As early as the 1980s PFOS and related compounds were found to be persistent and bioaccumulative and they were suspected to have toxic and / or carcinogenic properties in cases of long-term exposure. In higher organisms PFOS is mainly found in blood, kidneys and the liver. Both substances have long half-lives (residence times) in the human body of respectively 5,4 and 4 years for PFOS and PFOA. General population surveys have shown that the average concentration of PFOS in the blood is 20.7 µg/L and of PFOA 3.9 µg/L. In a study group exposed to contaminated drinking water with PFOA the average concentration was 354 µg/L and employees of a PFAS manufacturer showed blood concentrations of 1,320 µg/L of PFOS and 1.760 µg/L to PFOA.

Exposure to PFOS or PFOA occurs mainly through food, contaminated drinking water, breathing polluted (indoor) air or contact with treated materials such as packaging for food or impregnated clothing. Both substances are accumulated in fish, but PFOS to a greater extent than PFOA.

The United States population has shown a declining trend of concentrations of PFOS and PFOA. This is attributed to the change in production and a strong decrease of PFOA and PFOS applications in the last few years. However, there is an upward trend for PFNA (the sister of PFOA with 9 C-atoms), but these concentrations are lower than the concentrations of PFOS and PFOA in the human body.

In the toxicology of PFAS we see the phenomenon that in test animals a gender-dependent residence time in the body (half-life) is related to hormonally regulated secretion. The gender-dependent residence time is not uniform though, but depends on the substance and the animal species. The large differences in residence time between different species are also striking.

Mechanism

Some biological targets of PFOS and PFOA are similar. PFOS and PFOA accumulate in the liver, and both have the ability to activate the PPAR-α (peroxisome proliferator-activated receptor-α). Activation of the receptor in rodents leads to a series of biochemical events (mainly, but not exclusively in the liver), for example, the increased production of hydrogen peroxide (H₂O₂), which may result in oxidative stress by its generation of free hydroxyl radicals. These in their turn may lead to increased DNA damage or inhibition of intercellular communication. However, activation of PPAR-α also effects changes in the lipid metabolism. In addition, it has been shown that PFOS and PFOA induce several metabolizing enzymes, may induce apoptosis (the process by which a cell destroys itself from within) and interfere with hormone levels.

PFOS and PFOA are acutely toxic only at relatively high concentrations (in the order of milligrams). After chronic exposure to low concentrations, effects of PFOS and PFOA in the liver were reported. Enlargement of the liver and disturbance of liver function are consistently observed in different animals. It also appears that PFOS and PFOA may affect the reproduction in particular, while the exposure in the womb is critical for mortality, growth retardation or slower skeletal development in puppies. The causes of these effects on the offspring are unknown; possibly changes in thyroid hormone metabolism are involved here. Recent studies in mice also showed that immunotoxic effects of PFOS and PFOA may be expected at environmentally relevant concentrations. In general PFOS and PFOA were not found to induce mutagenicity and limited carcinogenicity limited.

Since 1976 potential health effects of PFOA and PFOS by occupational exposure of workers are being monitored by 3M, the major producer of these substances. To date, no significant associations between occupational exposure to PFOA and overall or cause-specific mortality statistics have been proved. For PFOS on the other hand, there are indications that occupational exposure results in abnormal liver function parameters and that it produces a significantly higher incidence of cancer. Especially cancers of the reproductive organs were more common in male workers with the highest and most prolonged occupational exposure. PFOS and PFOA can be transmitted through the placenta from mother to foetus. The concentration of PFOS in umbilical cord blood was 1.25 to 2.5 times lower than in maternal plasma. For PFOA there is no difference between cord blood and maternal plasma. PFOA can cross the placenta from mother to fetes. Also recent epidemiological studies showed a significant negative correlation between the presence of PFOS or PFOA in cord blood and birth weight.

Based on toxicity data, the CONTAM Panel of the European Food Safety Agency (EFSA) for human exposure to PFOS and PFOA has calculated a maximum tolerable daily intake (Tolerable Daily Intake, TDI) of 150 ng / kg per day, respectively 1.5 µg / kg per day. In addition, the EFSA notes that health effects to the public are not very likely, but that monitoring over time is certainly recommended.

(Quoted from literature nr. 33)

Behaviour in soil and water

The behaviour of PFOS (synonym for PFOS, PFOA and other perfluorinated compounds in soil and water is partly determined by their solubility, degradation, volatilization and sorption. A complicating factor in this is that the so-called derivatives may have significantly different properties.

Solubility

	PFOS	PFOA
solubility in surface water (mg / L)	370	9500

Compared with the solubility of other organic contaminants, and in relation to the concentrations of these substances measured at localised pollutions, the solubility of both compounds is relatively good. The solubility is affected by the salt content, pH, redox conditions, and salt formation / precipitation.

Evaporation

	PFOS (K salt)	PFOA (NH ₄ salt)
vapour pressure (Pa, at 20 °C)	$3.31 \cdot 10^{-4}$	$13 \cdot 10^{-3}$

Literature shows that PFOS (potassium salt) is substantially non-volatile (see table). And the ammonium salt of PFOA has a very low volatility, too. But PFOA is relatively volatile with a vapour pressure of 70 Pa. We cannot help noticing that large differences between the different forms are being reported. Literature sometimes gives different values for the same substance. In line with the low volatility are reports that the chemicals are detectable worldwide and even in the most remote areas such as the Arctic and Antarctic. However, there is still much uncertainty about the way in which the distribution and long distance transport takes place. One of the questions is to what extent differences in the volatility of the various forms play a role here.

Adsorption

Sorption of perfluorinated compounds in soil and sediments determines their behaviour and distribution in the environment, but there is little consensus on the distribution coefficients to be used in the assessment of the behaviour in soil and water.

From literature (lit. 13) it appears that $\log K_{oc}$ values determined in the lab, are systematically lower than $\log K_{oc}$ values derived from field data. Based on laboratory experiments, the adsorption can be reasonably well described by an average $\log K_{oc}$ of 3.0 for PFOS and a $\log K_{oc}$ 2.8 for PFOA. However, for a field situation average $\log K_{oc}$ values are derived from 4.2 for PFOS and 3.7 for PFOA. These differences show the importance of field research alongside laboratory studies.

Literature also suggests that these substances are not so much 'lipophilic' but rather 'proteinphilic' (protein-loving). A possible connection with the protein content of organic substance is reported to be probably accompanied by a correlation between the amount of protein and the amount of soil organic matter.

On the basis of the bandwidth in laboratory values and field values, and the lack of consensus on these, there is a wide bandwidth in the predictability of dispersing behaviour and the concentrations in the aqueous phase. Actually, we do not have sufficient knowledge of the behaviour in the soil.

(Biological) degradation

In view of the strong covalent bond between the fluorine and the carbon atoms, biological degradation is very inconvenient. Literature has no known cases of (biological) degradation in the environment. In the 2008 EFSA publication (lit. 28) PFOS is designated as extremely resistant to thermal, chemical and biological degradation processes. In order for PFOS to combust completely a temperature of 1,100 °C is required. Chemical oxidation occurs only under strongly oxidizing conditions, for example in the presence of activated persulfate or Fenton's reagent.

Sampling and analysis

Proper characterization of the behaviour of PFOS in soil and water starts with thorough sampling and analysis. This demands attention and a good preparation. In practice often low concentrations are involved and contamination is an important issue when sampling, for example by trace contaminants from sample material (Teflon) or the environment. Also, during the analysis contamination of the sample is possible and therefore a critical inspection of the analysis results is important. In the Netherlands we use the following reporting limits for PFOS: in soil 0.1 µg / kg and in groundwater 5 ng / L.

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