EXECUTIVE SUMMARY
FINAL REPORT

CLOSING THE CIRCLE?

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16 December 2022

VISION ON THE APPROACH TO THE PFAS PROBLEM

PFAS or perfluoroalkyl substances is the collective name for more than 6000 chemicals. These substances are made up of carbon chains, in which one or all carbon atoms are surrounded by fluorine atoms (-CF3 or -CF2-). Per- and polyfluoroalkyl substances are manufactured since the 1950s. PFAS do not occur naturally and are extremely persistent in the environment. The production and use of PFAS has led to serious contamination of soil, water and food and harmful exposure to humans.

In recent months the PFAS pollution problem in Flanders (Belgium) has once again reminded us that we live in a society in which 'life' and 'industry' have close encounters, sometimes too close. We keep bumping up against the limits of our industrial, densely populated system: pursuing sustainable production and consumption is more crucial than ever.

The sustainable management of materials and products is based on an approach that materials move in closed cycles as much as possible. A circular economy is a system where the complexity and functionality of materials is maintained for as long as possible, instead of breaking down a product into basic materials after use, incinerating or dumping it as waste. As little material as possible leaves the cycle. The circular economy needs materials that have a long service life, that ensures that products show little wear and are easy to maintain. As PFAS exhibit these properties, they seem to be able to make a good contribution to the circular economy.

However, in addition to circulating the flows, the circular economy must also ensure that the material chain does not get contaminated with substances that can affect the health of the user or the quality of nature and that uncontrolled emissions of harmful substances do not occur. That is why it is important to also provide safe evacuation points for polluting or harmful components in the circular material system, called 'safe sinks'. Controlled incineration or landfilling of inert materials can be such a safe sink. These safe sinks are necessary because without them, forever chemicals, such as PFAS, will remain in the environment forever with all that this entails.

The cycles of the circular economy run on renewable energy. On the one hand PFAS are used as a lubricant, coating,.. in wind turbines and other renewable energy technologies. On the other hand, the production and incomplete destruction of PFAS leads to emissions of hydrofluorocarbons with very high greenhouse gas potential (GWP – greenhouse warming potential). Gaseous hydrofluorocarbons contribute much more to climate change than CO_2.[1]

[1] Greenhouse gas emissions are expressed in CO_2equivalents, expressed as the *global warming potential* of the different gases. These are based on the effect of the gases at 100 years, compared to the effect of a similar amount of CO_2.

PFAS IN A CIRCULAR SYSTEM

Applying the above-mentioned principles to the PFAS cycle (Figure 1), it is clear that PFAS do not comply with the principles of circularity at all, even though they are products that can extend the life of materials.

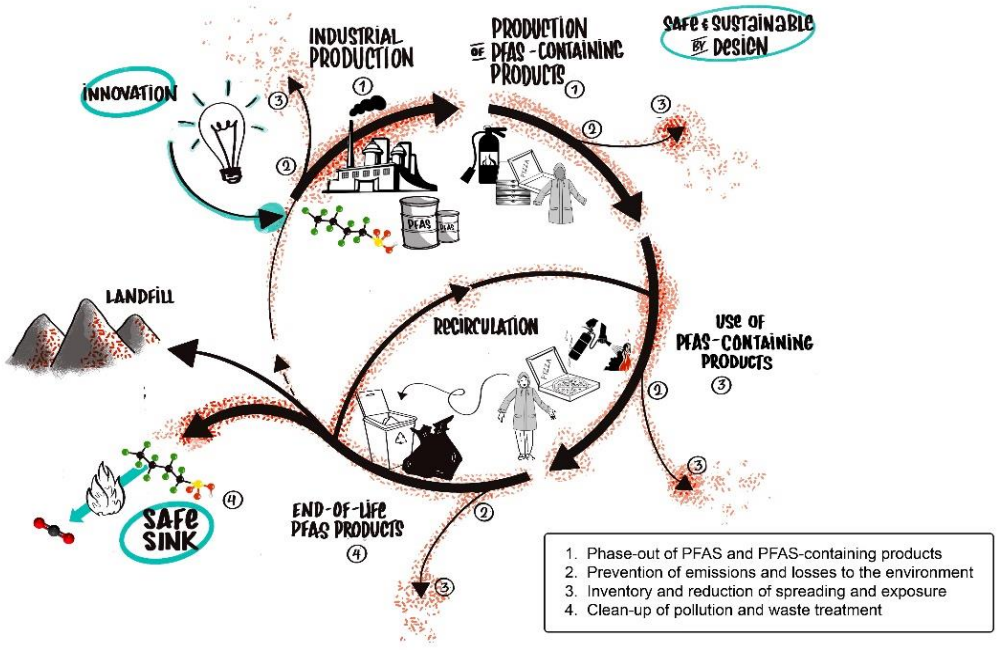

Figure 1: The PFAS cycle for the use of PFAS as surface treatment of products and the use of fluoropolymers in product applications; source: Government of Flanders.

- The **production of PFAS** starts from raw materials of petroleum and calcium or hydrogen fluoride. During production, many uncontrolled PFAS emissions appear to have occurred in the past, both into water and air. These uncontrolled emissions are the cause of soil and water contamination that we now observe in the vicinity of production sites and sites where PFAS was used (for example, locations where firefighter training exercises with PFAS-containing firefighting foam took place).

- The **production of products containing PFAS** (coated paper and clothing, firefighting foams, cosmetics, cookware,...) has also given rise to uncontrolled emissions in the past, mainly via wastewater and the disposal of water purification sludges (examples can be found in Willebroek and Ronse). It appears that manufacturers are not always aware, that the coatings or lubricants they use contain PFAS nor are they well informed of the health risks related to the spread of PFAS.

- The **use of PFAS in products** is widespread. In addition to a wide range of industrial products, many consumer products such as cosmetics, rainwear, food packaging,... also contain PFAS. Although they protect products from wear and dirt, it also means users are exposed to them. Weathering and wear of PFAS-containing products in-house enables absorption of PFAS by humans via inhalation of dust. In addition, PFAS-containing dust ends up in the domestic wastewater. The risks of this exposure are currently being examined, leading to new initiatives at European level to restrict or ban the use of PFAS in the production of these goods. For now, there is only a ban on the use of certain PFAS in firefighting foam.

- PFAS are **disposed of or recycled** as (household) **waste**. In an ideal circular system, materials are managed in a controlled manner, in order to be able to actively decide to recycle, safely reuse or safely dispose of it. Such a system also ensures that the discarded products can be raw materials for newly produced materials. These principles are insufficiently applied in the case of PFAS. Due to limited knowledge of application and use, materials containing PFAS are not managed in a controlled manner. Recirculation in the chain should be done in such a way that any risks for spread and exposure are well known and limited. By closing the material cycle, end-of-life materials can be used as raw materials for new PFAS. Disposal of the materials ensures that the products are broken down so that no spread or risk is possible. If closing the cycle is not possible, due to risks to health or the environment, maximum efforts must be made to ensure the safe disposal and degradation of the materials.

This cycle applies to the use of PFAS as a surface treatment of products and to the use of fluoropolymers in product applications.

Although recirculation is not an option for firefighting foams, there is still a need for a controlled management of these products. This in particular for stocks that are superfluous and will have to be destroyed due to the phasing out of certain extinguishing agents.

The material cycle presents producers with their responsibility to manage the materials they place on the market, on a permanent basis. The linear model, in which a producer produces and sells products without monitoring their further life course, needs to be omitted. This is also confirmed by the *Circular Economy Action Plan* of the European Commission, which has been advocating for making material cycles more sustainable since 2015. For example, operators who package products or import a packaged product into our country, remain responsible for the collection and recycling of the packaging material (via Fost Plus). There is also a system of extended producer responsibility (EPR) for F-gases[2]. However, for PFAS and products containing PFAS, such circular management is not (yet) in place. The European strategy "Safe and Sustainable by Design" encourages manufacturers to use sustainability and safety as a starting point in the design of products. In order not to repeat the mistakes of the past, this principle will also have to be paramount in the development of alternatives to PFAS.[3]

Table 1 provides an overview of the benefits and risks, using fluoropolymers from the perspective of 3 major European policy programmes: circular economy, low-carbon economy and toxic-free living environment.

[2] https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

[3] European Commission, Joint Research Centre, Boiler, C., FarcalL. Garmendia Aguirre, I., et al., *Safe and sustainable by design chemicals and materials : framework for the definition of criteria and evaluation procedure for chemicals and materials*, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2760/487955

Strategy, policy	Potential benefits	Potential risks
Circular economy	High durability, longevity, miniaturisation of products (less waste)	Although fluorspar (CaF_2, fluorite) is on the EU's list of critical raw materials, there is almost no information on recycling or recycling rates. Fluorinated polymers are often integrated in components which make them difficult to recycle
Low-carbon economy	Use in renewable energy applications, reduced energy need (lighter vehicles, etc.)	Raw materials with greenhouse potential are used in production processes and are likely to form when heated/incinerated at temperatures below that at which they mineralise fully.
Zero Pollution Ambition/ toxic-free environment	Longevity may avoid the need for new products due to wear	Use of chemicals of concern, including PFAS, organochlorines and heavy metals, will in practice lead to emissions and hence to risks during their production, use and at end-of-life phases. The risks may stem from either the substances themselves or their by-products and degradation products, both of which may accumulate and cause long-term, irreversible pollution and impact humans, biota, and the wider environment.

Table 1: Impact of the use of fluoropolymers or different EU strategies; source: EEA

POLICY IMPACT

The evaluation of this PFAS material cycle provides several starting points for developing policy. This must be a systemic policy that intervenes in the various steps of the production, processing and use cycle. In addition, the objective must be to limit the impact on the environment and on health as much as possible. This policy consists of 4 perspectives:

1. Phasing out PFAS and products containing PFAS;
2. Preventing or limiting emissions and losses of PFAS into the environment;
3. Identifying and minimising the spread of pollution and the exposure of the population, fauna and flora;
4. The remediation of contaminated sites and the treatment or the disposal of waste.

The policy approach should be further supported through raising awareness, sharing knowledge, monitoring, research, legislation, licensing and enforcement.

Policy angle 1: Phasing out PFAS and products containing PFAS

The European 'Chemicals Strategy for Sustainability (CSS)' aims to prevent toxic substances from being included in products at the design stage. It does not allow harmful substances unless they are indispensable for health and safety reasons or if they are crucial for society to function. The strategy (Figure 2) [4] includes a comprehensive set of measures for the coming years to address the use of PFAS and the pollution they cause. The use of PFAS in the EU will have to gradually disappear with exception of a very limited set of applications. On 6 October 2021, Belgium joined the position of other European member states (the Netherlands, Germany, Denmark, Sweden, Norway) to ban the production, sale and use of PFAS in Europe.

[4] https://www.consilium.europa.eu/nl/infographics/eu-chemicals-strategy/

The most source-oriented measure to limit the spread of PFAS into the environment and to humans, is to prevent the production, sale and use of these products. This measure can be taken at European level through a REACH restriction procedure. Within that procedure a ban will be installed on the production of a certain product or a group of products, on placing it on the market and on using it. This also applies to the use of PFAS in mixtures or as an additive in a material or object. Usually, a transitional period is put in place so that the products are phased out over a certain period of time.

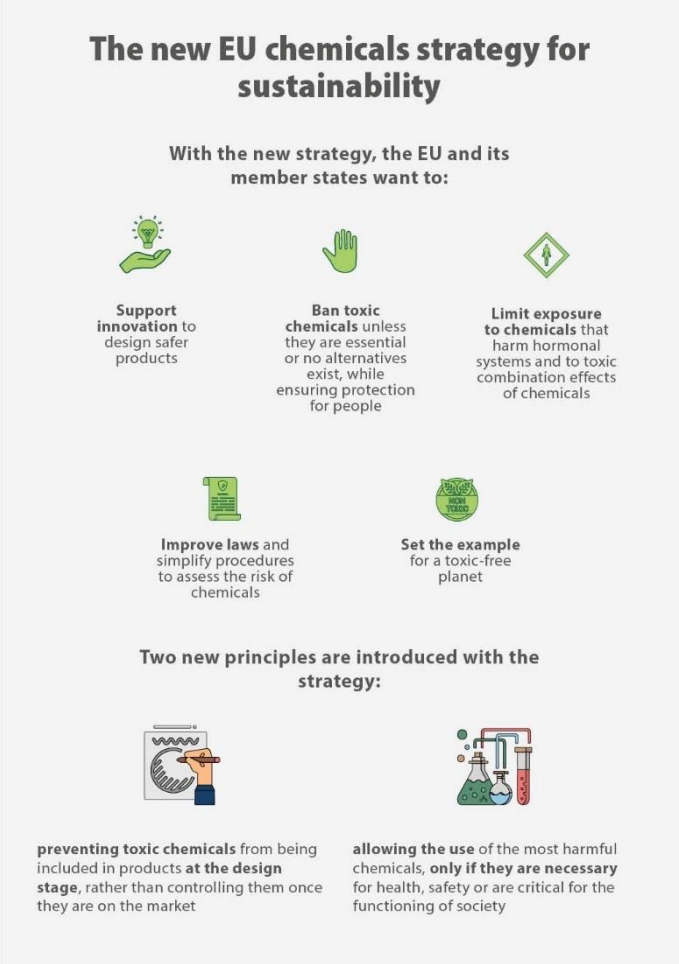

Figure 2: New EU chemicals strategy for sustainability; source: European Commission

Both Member States and *the European Chemicals Agency* (ECHA) can initiate a restriction. The use of PFOS and PFOA in firefighting foams was banned several years ago through this procedure. Currently a procedure to phase out all use of PFAS in firefighting foams is on its way. An additional procedure will be initiated early 2023 to restrict all PFAS in all applications. When such a ban is imposed, alternative materials, with similar properties and less impact on people and the environment, will be sought. Replacement by materials with other harmful effects, i.e. *'regrettable substitution'*, should by all means be avoided. In order to avoid these regrettable substitutions, a very broad restriction of all molecules containing a CF_2 group is advocated. However, in some cases no alternative is available yet. An important part of the European debate in the restriction procedure will therefore be about delineating which PFAS applications are considered essential and irreplaceable.

A general restriction has the effect that both routes, 'production' and 'recirculation' in Figure 1, will be closed. This will be the moment when large amounts of PFAS waste will arise and will have to be disposed of in a *safe sink*. This is why the restriction will also have to be accompanied by the development of additional and sufficient processing and disposal capacity.

According to the current schedule, the general PFAS restriction will not be effective until the beginning of 2025 at the earliest. It will then include transitional periods of several years. In order to limit the spread and harmful effects of PFAS more quickly, the industry will have to proactively take initiatives to keep PFAS out of their products. In several European countries initiatives are already underway to support substitution by disseminating information, using labels and conducting research.

Unfortunately, we find that in Flanders, companies are very reluctant to communicate about initiatives that the industry is taking in this area. The lack of even confirming their willingness to engage in finding alternatives makes it difficult to establish a coordinated approach as of yet.

In the context of the revision of the Industrial Emissions Directive (IED), the mandatory establishment of an environmental management system is being investigated for large companies. One part of this is the development[5] *of a chemicals inventory* of hazardous substances (*chemicals management system*). The *chemicals inventory* obliges the operator to carry out a risk analysis for the use of hazardous substances and states that the operator must actively look for safer alternatives to the hazardous substances used (more than Substances of Very High Concern (SVHC)).

Policy angle 2: Preventing and limiting emissions and losses of PFAS to the environment

The PFAS cycle, as presented in Figure 1, shows emissions and losses of PFAS at every step of the chain. Emissions can occur via specific emission points (chimney, discharge point) or by uncontrolled flows through crevices, windows, doors, leaks, leaching (non-guided emissions). Guided emissions occur in the production of PFAS and PFAS-containing products in industry, or at waste and wastewater treatment plants. The large spread of PFAS means that we now have much more to do with diffuse pollution. Pollution that occurs in many places and in all compartments (water, soil, air, materials) and is not only caused by industrial activities, but also by, for example, fire brigade interventions, use of household products,... This diffuse pollution cannot be combated by only tackling the point sources.

The emission of PFAS from industrial processes into the environment can be addressed by permit policy. Permit conditions have to provide the best level of protection for people and the environment, by applying best available techniques (BAT). BAT is the reference for drawing up the general, sectoral and special permit conditions and the basis for environmental permits in Flanders. The permit obliges companies to use techniques that limit the impact on the environment as a whole, both in processes and for emissions. Flemish and European BAT studies have laid down what these techniques and the associated performance levels are. The start-up of new BAT studies in Flanders and the contribution of Flemish knowledge in the European BREFs ([6]*BAT Reference documents*) ensure that industrial practice is adapted to the most up-to-date state of expertise and technology. For PFAS, and by extension all substances of very high concern, minimisation of emissions is essential. This means striving for zero emissions of these substances. As a result, measures that sometimes go beyond what is achieved with the current BAT instruments are required. In addition to fixed standards, the regulation of substances of very high concern should therefore foresee provisions to further limit emissions in the long run.

[5] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:nl:PDF

[6] https://omgeving.vlaanderen.be/nl/beste-beschikbare-technieken-bbt

In addition to the approach at source, PFAS and other diffuse pollution also requires a systemic approach: an approach at different points in the chain of production, use and waste processing. If not, we will jeopardise the objectives in other policy areas such as climate, waste and circular economy. An approach that focuses only on one compartment leads to a transfer of the problem to the next compartment and other types of emissions.

The Government of Flanders is currently working with a temporary action framework for PFAS in various environmental compartments. It offers an approach for risk locations, environmental health focus areas and it provides adjusted limit values for drinking water, surface water, earthmoving, soil improvers, air, return of dewatering water, discharge of waste water, bathing and recreational water. It aims to maximise the reduction and prevention of PFAS exposure, where it is essential to evaluate all sources and routes of exposure. Adjustments to the temporary framework for action are always introduced with an eye for the necessary transitional measures to avoid legal uncertainty in ongoing projects. The temporary framework for remediation of soil and groundwater will be converted into a standards framework at the end of 2022 through additional decisions by the Government of Flanders, which provides a stable legal basis. For the discharge of waste water, adjustments are proposed in this final report. These will be further legally anchored through future Vlarem (the Flemish legislation on permitting) amendments. More research is needed for the air compartment and a study is planned for 2023.[7][8]

Policy angle 3: Identifying and minimising the spread of pollution and exposure of the population

Figure 3 shows the dispersion routes of PFAS and the relationship between different environmental compartments. Emissions are generated at different stages of the product cycle (Figure 1, label 3). In addition to emissions from current production and use, there is also the spread of PFAS from contaminated zones into soil and groundwater.

In addition to the environmental compartments water, air and soil, the indoor environment also plays an important role in exposure to PFAS. The use and weathering of PFAS-containing products in the home leads to the formation and inhalation of PFAS-containing dust particles and aerosols.

It is important to gain insight into the interactions between the different compartments. After all, the persistence of the PFAS molecules causes long-term accumulation. This means that compartments, such as drinking water, where a limited PFAS load is currently measured, may eventually show concentrations that are too high due to accumulation. Furthermore, the high mobility leads to easy transfer between compartments, which ultimately lead to accumulation in water or in humans, fauna and flora.

The treatment of PFAS-containing waste or residual flows must also take into account that the molecules are moved between the compartments, as long as no degradation takes place. Soil remediation ensures a transfer to the aqueous phase, followed by adsorption on activated carbon during filtration. As long as the activated carbon is not regenerated or burned with complete destruction of the PFAS molecules, the pollutants will remain in our living environment.

[7] Flemish government, From Knowledge to Action, second interim report of the PFAS commissioner, March 2022, p. 71-132
[8] https://www.vlaanderen.be/pfas-vervuiling/pfas-normenkader-voor-bodemsanering-en-grondverzet

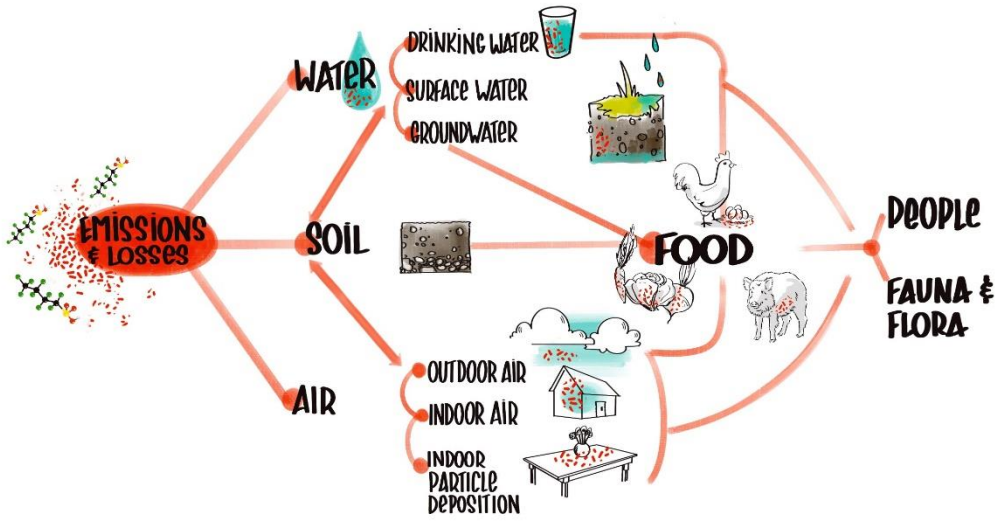

Figure 3: routes for the spread of PFAS contamination; source: Flemish government

It is necessary to consider how the spread and exposure of the pollution can be reduced as efficiently as possible in order to avoid the risk of damage to health and nature. Environmental and health goals come together in this risk-based approach. Since not all effects of PFAS are yet known, the precautionary principle is also used: prevention is better than cure. This forms the basis for drawing up *no regret* measures. These are measures of which we will later have 'no regret' when it comes to public health.

No regret measures are taken on the basis of the data known so far and in the awareness and transparent communication that a lot of knowledge is not yet present or that is incomplete. It concerns advice to limit eating vegetables or eggs from your own garden, or to avoid dust production. These measures are applied as soon as possible after a serious medical environmental signal and they are independent of any future scenario. As more data and insight become available along the way, the measures are adjusted in time, space and content.

No regret measures are formulated from a public health point of view. This means that:

- the measures are based on early detection and intervention to limit or prevent environmental health damage,
- the measures have the objective of preventing potentially greater calamities by reducing additional exposure to chemicals as quickly as possible,
- the basis of the measures lies in a consideration of the risk of spreading the exposed population and the possible effects on health,
- the measures have the objective of informing the population in an action-oriented manner with special attention to risk groups.

An up-to-date overview of the no regret measures is provided on the PFAS website. *No regret* measures are recommendations for the population. They indicate what you can do to limit your exposure. Most measures relate to personal behaviour and are not enforceable (e.g. consuming home-grown vegetables with moderation). Some measures were converted into enforceable measures by means of a municipal decree (e.g. covering loose soil, limiting the dispersion of soil, not allowing children to play on undeveloped land).

The spread of the pollution ultimately leads to exposure of humans, fauna and flora. The way in which this exposure occurs and the effects it causes are the subject of environmental health research. Here an important role is reserved for the research on human biomonitoring, the planned large-scale blood tests and the work of the Policy Research Centre for Environment and Health. Health-related limit values indicate from what kind of exposure negative health effects can be expected. One can see a maximum dose for the lines that meet in 'people' in Figure 3. This figure shows that the translation of these health-related limit values into maximum levels per compartment and emission limit values is complex matter. The relationships between emissions, dispersion between compartments and exposure are investigated using exposure models. In Flanders, this is the S-Risk model. The research into the PFAS contamination allows to further improve these models.[9]

Policy angle 4: The remediation of contaminated sites and the treatment or disposal of waste

The inventory of risk sites in Flanders[10] shows that more than 3/4 of the training locations for firefighters have PFAS contamination of the groundwater and often also of the soil. It concerns hundreds of contaminated sites spread across Flanders. The inventory of industrial sites is still ongoing, but based on examples in Zwijndrecht, Willebroek and Ronse, we can expect that several additional contaminated sites will be identified. The evaluation of the necessity and the method for remediation for these locations must be made on the basis of further (descriptive) soil research. Remediation must ensure the demarcation of the contamination and the prevention of further spread or exposure.

In hot spots, different sources or routes of exposure come together, vulnerable groups are present and there is possible prolonged exposure. A coordinated and integrated approach to reduce that exposure is required. In addition to the remediation, discussions are conducted with local actors to establish which additional measures can be taken to limit exposure and risk. In a non-hotspot, the approach is aimed at integrated remediation: limiting human exposure, impact on fauna and flora and spread. Instruments to arrive at a substantiated remediation approach are: the assessment values soil remediation standard, the methodology for 'clear indication of serious soil contamination (DAEB in Dutch), the codes of good practice and the S-risk model. The responsibility for the elaboration of the remediation approach lies with the certified soil remediation experts.

The development of soil remediation techniques poses another important challenge. Through BAT studies, the available techniques are inventoried and evaluated for their feasibility and cost. Various research institutes and companies are working on innovative techniques that are or have been developed on a lab-, demo- or pilot-scale. Through exchange of knowledge and further demonstration, the upscaling of these techniques can be accelerated.

Research shows that PFAS are also present in material streams that are recycled on a large scale: organic waste, construction and demolition waste, sludge, paper. Further research is needed to determine to what extent this poses a risk and how the objectives of sustainable material management can align with the protection of public health. After all, these are flows that contribute significantly to achieving the recycling targets as stipulated in the European waste strategy and the *Circular Economy Action Plan*.[11]

[9] https://s-risk.be/en
[10] https://www.vlaanderen.be/pfas-vervuiling/maatregelen-per-gemeente#pfas-kaart-vlaanderen
[11] https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0023.02/DOC_1&format=PDF

The substitution of products containing PFAS and the ban on the use of PFAS will give rise to large amounts of PFAS-containing waste. An example is the unused stocks of PFAS-containing firefighting foam at airports and fire brigades. Thermal processing is currently (December 2022) the only route used for destruction: incineration in waste-to-energy plants, cement kilns or industrial waste treatment plants. The roll-out of a measurement campaign of chimney emissions and deposition measurements must further demonstrate whether the desired destruction is achieved. This will make it possible to also draw up emission standards.

Alternative destruction methods via pyrolysis or chemical treatment are still in a research phase. This is something where Flemish research institutes are also focusing on. PFAS that are separated from water streams via selective filtration can potentially be destroyed by chemical destruction.

When choosing treatment options, the waste hierarchy and the European ban on the landfill of combustible waste must be taken into account and the proximity principle must be respected. It is important to remove waste as close as possible to the source, solutions should be sought as little as possible abroad.

CONCLUSION

The PFAS commissioner was appointed by the Government of Flanders in June 2021 to bring coordination and communication to the approach of the PFAS problem. The original 1-year term was extended by 7 months and at the end of December 2022, the PFAS commissioner presents several clear results. Concrete measures were taken to solve the problematic situation around 3M and the Oosterweel works. Furthermore, the basis was laid for a better Flemish approach to the environmental and health effects of chemical pollution.

RESULTS AND OUPUT

Thanks to the operation of the teams assisting the commissioner, the scientific knowledge building and exchange around PFAS accelerated. The PFAS dossier became a starting point for a better substantiated and stronger approach to persistent chemicals and substances of very high concern in Flanders.

The operation of the PFAS commissioner has led to the emergence of a powerful learning network with a formal mandate and a very flexible work approach, focused on interaction and exchange and answering changing questions. An important headline in this operation is the strong link between research and policy, the involvement of stakeholders and the smooth interaction between the Flemish and federal level and the scientific institutions.

The commission presents following concrete results:

- **Research insights** for all environmental compartments: the PFAS assignment brought together and discussed the results of more than 40 (often innovative) research projects on the risks, spread and impact of PFAS.
- The **temporary policy framework** for dealing with PFAS contamination in different environmental compartments. The action framework tightened the standards and assessment values for PFAS emissions and soil use.
- **PFAS Action Plan**: A strategic plan with 50 actions for the period 2022-2024 in which various government partners work together to make PFAS policy turn into tangible results.
- **Hub for Substances of Very High Concern**: a governance approach, based on the functioning of the PFAS mission, which indicates a new structured approach for the policy on substances of very high concern and which builds on the work method introduced by the commissioner in recent months.
- **Remediation agreement and Remediation covenant**: Agreements and a framework of arrangements with 3M on the one hand and the local actors on the other, that form the basis for resolving the conflicts between the parties and establishing clear agreements for the further approach to pollution on and around the 3M site and the Oosterweel works. In addition, a programme is being set up to monitor the health of local residents on a long-term basis.
- **PFAS explorer:** Open data environment of The Flanders Subsurface Database that was built as a central system where measurement data of PFAS in all different environmental compartments are brought together and visualised.
- **PFAS website**: https://www.vlaanderen.be/pfas-vervuiling, the website where all the information about the PFAS problem is available and continuously updated. All information and insights are shared with the general public via the website

All this was elaborated in 4 reports, compiling almost 600 pages of information and insights about PFAS in Flanders (**Figure 4**).

Figure 4: Interim reports from the PFAS commissioner

SYSTEMIC APPROACH

Since the 1970s, environmental policy was based on the approach of point sources. Factories caused environmental pollution through chimneys and discharge points. This was addressed by imposing permit conditions on the operators, both in terms of discharge and the production processes used. This approach of point sources and industrial installation is the basis of the environmental policy on (industrial) emissions. PFAS show that more and more we are dealing with **diffuse pollution**. Diffuse pollution occurs in many places and in all compartments (water, soil, air, materials) and is not only caused by industrial activities, but also by fire brigade interventions, use of household products,... Combating diffuse pollution cannot be done by only tackling the point sources and therefore requires a different kind of policy.

PFAS and other diffuse pollution requires a systemic approach i.e. an approach at different points in the chain of **production, consumption and waste processing**. Without this approach the objectives in other policy areas such as climate, waste and the circular economy will be jeopardised.

Many components of PFAS family are classified as substances of very high concern due to the high persistence, mobility and human toxicological and ecotoxicological properties. Increasing scientific knowledge identifies more and more **risks for humans and the ecosystem**, especially for non-polymer PFAS. Depending on the chain length and the functional group, mobility (short chains) or bio-accumulative character (longer chains) causes spread and risks. Further insight leads to a far-reaching tightening of the limit values and environmental quality objectives. The European Commission's recent proposal to review the Water Framework Directive therefore includes new environmental quality standards for a list of 24 non-polymer PFAS.[12] It proposes particularly strict values in terms of water quality and the presence of PFAS in biota. At the same time, a weighting according to **Relative Potency Factors** (RPF) is introduced, which recently has also been applied in the Netherlands. This weighting makes an important distinction between the human toxicological effects of short versus long chain PFAS, which is considered when adding concentrations for

[12] European Commission, COM (2022) 540 final, Proposal for a Directive amending the Water Framework Directive, the Groundwater Directive and the Environmental quality standards directive in the field of water policy

evaluation against target values. This gives the short chain PFAS (PFBS, PFBA) a much lower importance in the evaluation of water quality. In Flanders, this approach has not yet been introduced; VITO is examining the use of RPFs for testing soil contamination and transfer to humans on behalf of OVAM.

The strict threshold proposed by EFSA (tolerable weekly intake (TWI) or the European Commission (environmental quality standards) are **long-term targets** that can (and should) be achieved by addressing the different phases of the material cycle of PFAS and products containing PFAS. It is not possible to achieve these goals by formulating extremely strict limit values (e.g. values below the limit of determination) on a single compartment (e.g. discharge standards, soil remediation standards). Only through **combined action on all phases in the material cycle**, a so-called systemic approach, which is depicted in Figure 5, overall exposure will decrease:

1. Phasing out PFAS and products containing PFAS;
2. Preventing or limiting emissions and losses of PFAS to the environment;
3. Identifying and minimising the spread of pollution and exposure of humans, fauna and flora;
4. The remediation of contaminated sites and the treatment or disposal of waste.

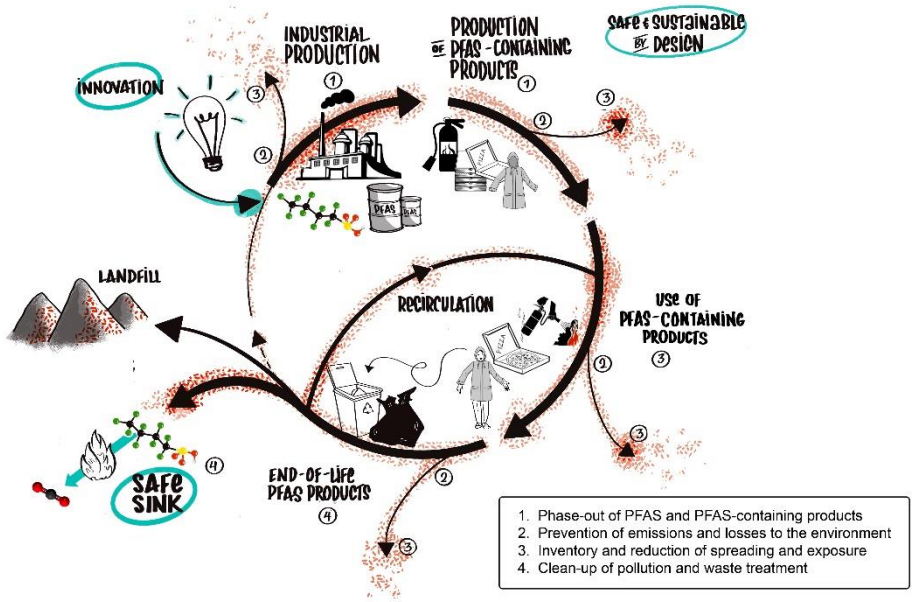

Figure 5: the PFAS cycle for the production and use of PFAS as surface treatment of products and the use of fluoropolymers in product applications; source: Flemish government

Within the PFAS assignment, the PFAS Action Plan and the new Hub for Substances of Very High Concern, actions were and are spread over these 4 policies. As PFAS do not cause acute toxicity or effects, limiting risks cannot be done by short-term interventions or measures. PFAS policy should therefore focus on actions and effects that work in the **medium and long term**.

The systemic approach requires cooperation and complementarity between the **different policy levels.** The phasing-out measures are taken by the European Commission, after input from the Member States. Substitution and product policy is driven from the Belgian federal level. The elaboration and implementation of the permit policy requires an interplay between the regional,

provincial and local level. Studies on dissemination and impacts take place in both a Flemish and European context. Prevention and advice on exposure takes place in individual contacts between medical environmentalists and citizens. In the elaboration of the policy, sufficient attention must therefore be paid to the different roles, and coordination must be brought to the approach at all levels.

All these initiatives are important, but PFAS contamination **is only one of the environmental risks** to respond to in Flanders. We must avoid entering into a PFAS tunnel vision. Life in a densely populated industrialised region puts a lot of pressure on the environment and on the health of its inhabitants. Meanwhile, climate change also presents us with major challenges on a global scale. Tackling an environmental problem can never be simple. If we choose to solve only one problem in a singular way, it will inevitably lead to the aggravation of another problem, with potentially greater consequences. For example, we must continue to evaluate whether the search for solutions to PFAS contamination does not cause an undesirable impact on global warming, material use and circularity, energy use, spread of particulate matter,… That is one of the big challenges of the **systemic crisis** in which we find ourselves.

Crucial in the further policy development will be the evaluation of what additional pressure a certain area can still handle, in terms of environment and health, taking into account the risks already present. The **environmental and health usage space** must form the basis for future permit policy. This should be done according to an integrated approach, aiming to prevent and control emissions in all environmental compartments in a certain region and taking into account cumulative effects. This approach was precisely the reason to take more far-reaching remediation measures or *no regret* measures in the hotspots of Zwijndrecht or Willebroek. The concept of the environmental and health area of usage space forces us to think about interactions between different stressors (traffic, industry, noise, particulate matter, chemicals,…) and whether it is possible to accept additional emissions or risks in a particular zone. The integrated approach (taking into account different compartments) is already the starting point of the Flemish environmental permit and of the European Industrial Emissions Directive. This integrated approach should be extended to include an assessment of the carrying capacity of an area in terms of cumulative environmental and health pressures.

ACHIEVEMENTS

The PFAS assignment has given impetus to very concrete realisations, measures on all aspects of the PFAS material chain, that have ultimately led to a reduction in the spread and risks for the population.

PFAS production: Due to the safety measure in October 2021 and because of the stricter discharge standards for industrial waste water, 3M has temporarily stopped or adapted various processes. The wastewater from all production processes containing PFAS is buffered and, if necessary, disposed of. The contaminated soil on the site is removed. In May 2022, 3M committed itself not to restart C4 PFAS production in Zwijndrecht. This is the product group, based on PFBS.

Future of PFAS and products containing PFAS: At the European Environment Council of 24 October 2022, Belgium urged the other Member States to adopt a rapid and far-reaching restriction, a systemic approach and an improved exchange of good practices and information. This has put the main lines of operation of the PFAS commissioner on the European agenda.

Prevention of emissions: Through the new and more stringent (science-based) temporary framework, adjustments to VLAREM and changes to the individual permits, the discharge standards for almost all PFAS processing companies were tightened. The Enforcement Section of the

Environment Department ensured enhanced follow-up and enforcement of the applicable standards with targeted campaigns. 3M was imposed reduction measures to accelerate the reduction of discharges into the river Scheldt. Since September 2022, water extraction has resulted in a greatly reduced flow rate from the Palingbeek to the Scheldt. In the long term, this discharge will be completely stopped.

Limiting spread and exposure: Based on OVAM's inventory of risk sites, more than 600 exploratory soil surveys were carried out at firefighting sites. In more than 1,000 locations the Agency for Care and Health has announced no regret measures that limit the exposure of the population, pending further research and possible remediation. In about 20% of the cases, the measures were stopped after further soil investigation. In the areas surrounding 3M, there will be a large-scale blood test, an epidemiological study and a health surveillance program. Here, the health effects of PFAS are mapped out in order to take action where necessary.

Remediation and processing of waste: Due to the fact that the site of the former paper mill De Naeyer in Willebroek was still under development and elevated PFAS concentrations were detected spread over the entire site, OVAM decided in December 2021 to clean up the entire residential zone, by excavating the contaminated top layer and replacing it with clean soil. It concerns the areas with private homes and public spaces with a higher risk of exposure (e.g. playgrounds). In this way, the different routes of exposure to PFAS are tackled, which immediately eliminates long-term health risks for residents. In Zwijndrecht, the excavation of the contaminated top layer in the residential zone closest to 3M will start from May 2023. In the meantime, a pilot study for soft remediation of agricultural land via phytoremediation is underway in the neighbourhood. The development of a measurement method for PFAS in chimneys and a first measurement campaign are the stepping stone to more thorough research into the destruction of PFAS and the use of incinerators as *a safe sink*.

These are some examples of how tackling the PFAS problem over the past year and a half has led to tangible results and the reduction of public health risks. The real effects of the assignment are new contacts between and with people, who are confronted with PFAS contamination every day at work, on the site or in their homes. They have shared their views and insights on the matter and have come together to find solutions to tackle the complex problem that is PFAS.

FULL CIRCLE?

The PFAS mission has come to an end but the PFAS circle is not yet complete. Major challenges remain to sustainably manage the production, use and disposal of products containing PFAS with a focus on nature and human health. Thanks to the efforts of many stakeholders in the past year and a half, major steps forward have been taken, causing a deflection of the trajectory.

We have started the turn towards a more sustainable policy on substances of very high concern. I am confident that the Government of Flanders, led by the many experts and in close cooperation with science, will steadily and with ambition continue this process towards a model with (more) sustainable production and sustainable consumption.

Prof. Dr. Karl Vrancken
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