Circular Economy Lab & Observatory

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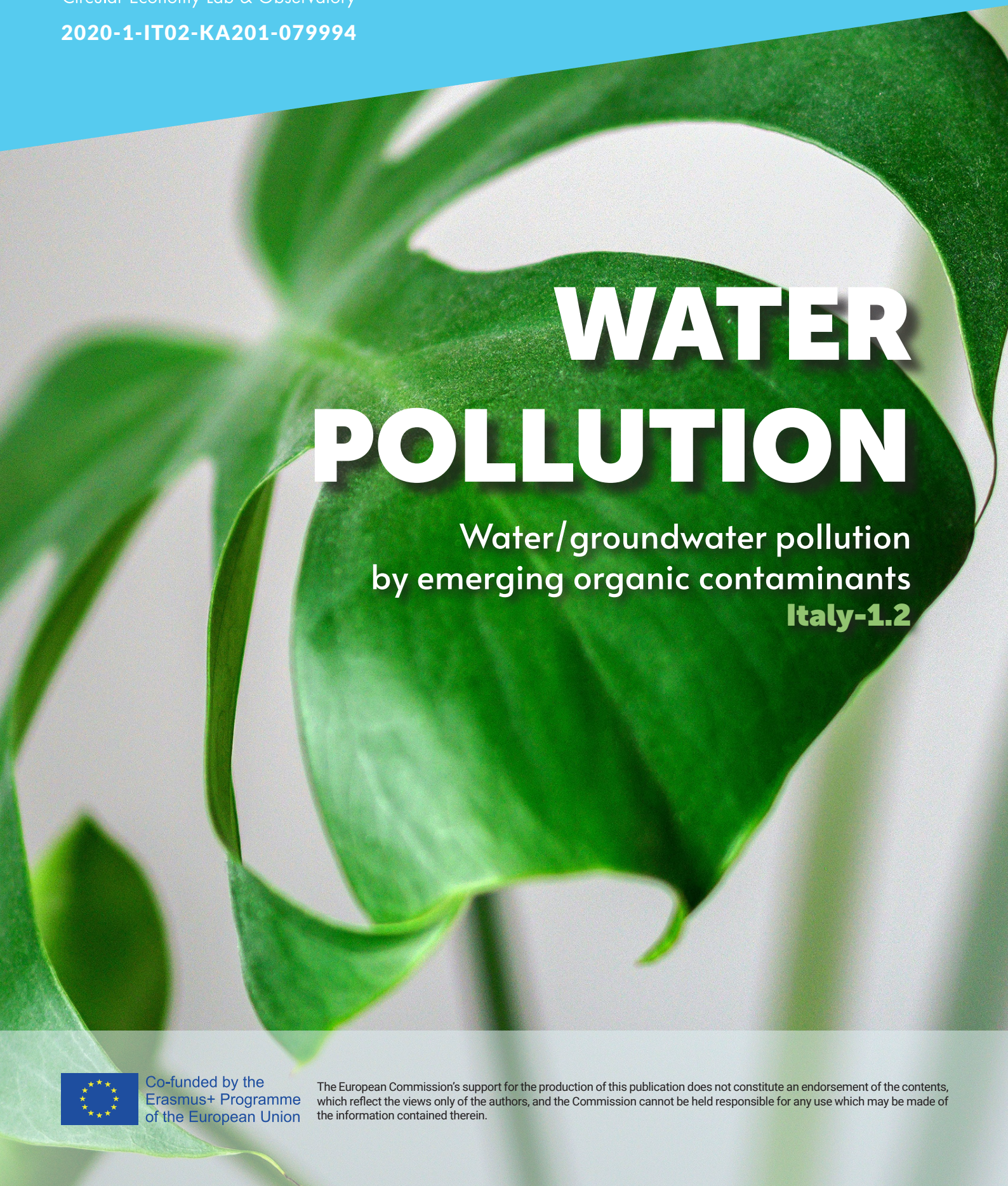

WATER POLLUTION

Water/groundwater pollution by emerging organic contaminants

Italy-1.2

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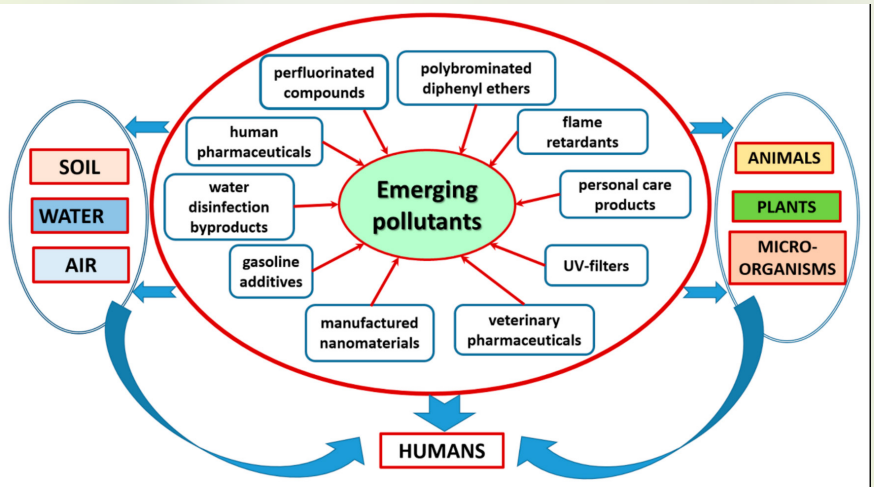
INTRODUCTION

Environmental pollution has become one of the most challenging and everyday issues and the degradation of environmental quality has evolved worryingly with industrialization and urbanisation. It is a serious problem at global level because it can affect flora, fauna and human health. Water is one of the most vulnerable environmental compartments. Two million tons of pollutants are daily discharged into water around the world. Groundwater isn't untouched: cultivated areas or animal wastes, effluent discharged from waste water treatment works into ponds that infiltrate to groundwater or to surface water, which then interacts with groundwater.



https://www.mdpi.com/water/water-13-00181/article_deploy/html/images/water-13-00181-g001.png, picture from Occurrence and Fate of Emerging Pollutants in Water Environment and Options for Their Removal BY Ionela Cătălina Vasilachi, Dana Mihaela Asiminicesei, Daniela Ionela Fertu, Maria Gavrilescu; Creative Commons Attribution (CC BY) licence (http://creativecommons.org/licenses/by/4.0/)

The term emerging contaminants, (EC), or emerging pollutants, EP, is used to describe substances which are not regulated yet, but may be of environmental concern.

They are not commonly monitored in the environment, but have entered the environment and have suspect environmental and/or human health impacts.

EC can be roughly divided into non organic , for instance heavy metals, and organic. Examples of Emerging Organic Contaminants are pesticides, pharmaceuticals, endocrine disrupting agents, and many others that come from industries and our homes.

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In fact, they derive from a wide range of substances produced by humans, and used in our daily lives, such as in personal care products. There is another group of pollutants named "contaminants of emerging concern".

This name usually refers to substances that are not new at all – they have been used and are well known, but their effect on the environment is not being studied enough, mainly because of lack of information regarding the magnitude and frequency of risks on human health and the environment [6].

In fact, one of the problems with the EC in general, is the possibility of getting useful information because:
the number of emerging pollutants is huge, and grow as time goes by. According to the NORMAN database, (www.norman-network.net), there are more than 700 compounds grouped into 20 classes of emerging pollutants;
the cost to monitor these substances is generally high;
the analytical techniques to trace them has been developed only recently;
these pollutants could be dangerous even at low concentration;
the effect of so many pollutants could be dramatically severe, but it is often not considered.
In the following paragraphs we are going to face with the problems the ECC causes, how we can trace and finally treat them.

Industrial waste water, pic from the article: https://www.laci.it/laciw/servizi-analitici/analisi-ambientali/acque-di-scarico/

PROBLEM DESCRIPTION

There are so many emerging organic contaminants that can be found everywhere, and as there are a lot of various substances, not all have been regulated yet . The following are just some categories of EC:

– pharmaceuticals. From anti-inflammatory to antibiotics, residues of these drugs can be found in water effluents. They reach surface water via urban wastewater or hospital sewers, but they can also reach groundwater. Antibiotic concentration is particularly high in in rivers in poor nations, so high as 300 times greater than the safety limit, but also in Europe there are cases of concern;

– organic UV filters. UV filters enter especially sea water, due to the recreation activities near the beaches, but they have been found also in rivers, lakes and groundwater. However, the major source are the effluents of the wastewater treatment plant. As for other ECC, treatment plants are not very effective in the removal of organic UV filters; [6]

– PFAS. The per- and polyfluorinated alkyl substances are a group of a large (more than 4700 compounds) and widely used man-made chemicals that accumulate over time in humans and in the environment.

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Domestic use of pesticide, Pic by Saverio Romeo

PFAS have been detected in the environment across Europe, reaching also drinking water. The two most known of PFAS are: perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). They are used in a big variety of consumer products and industrial applications because of their chemical and physical properties. PFAS can be found in consumer products such as polishing and cleaning agents, non-stick metal coatings for frying pans, paper food packaging, creams and cosmetics,... they are (or degrade to) very persistent chemicals, and can contaminate dust and air, while food contact materials can contaminate food.

PFAS are chemicals that accumulate in humans, animals and the environment. Their toxicity is high for different human internal organs;

- pesticides. They differ from other pollutants because they are designed to have effects on the organisms, plants or insects and can have an impact on the environment. Even if the use of pesticides in the EU countries is regulated on the basis of high protection goals for human health and environment, there is still a chance for the surface waters and groundwater to be contaminated. In general EP are considered toxic, and low concentrations such as in the order of nanograms per litre, can bring consequences, such as hormonal interference in fishes, genotoxicity, carcinogenicity in lab animals, endocrine disruption.

Also, as these contaminants pass through things like drinking water, treatment plants, then new products are created- that have not been characterised chemically yet.

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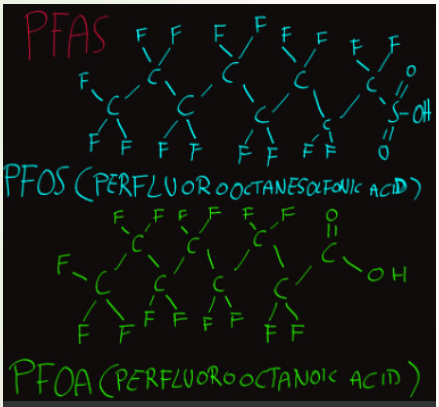
The presence of some chemicals at the lower level (micrograms per litre) in the aquatic environment has become more evident due to the creation and improvement of analytical techniques (in particular a liquid chromatography mass spectrometry, which permits to detect the polar compounds such as pharmaceutical and metabolites).

The environment is contaminated by myriads of emerging contaminants (the chemicals present in the aquatic environment at micrograms per litre concentration range and below), and because of this range of concentration, they are also called organic micropollutants. [1] The European Commision gives off a watch list with the limit of the substance and the compounds that are dangerous for the human being. Drinking water is of particular interest for the European Commission.
In fact the first substances in its watch list for the risk for human health are present in water and they have maximum values.



Structure of two of the most well-known PFAS compounds. Pic By Saverio Romeo

POSSIBLE SOLUTIONS

To limit the problems caused by the EOC, at first we need to be able to monitor them. The main analytical techniques for EOCs monitoring are mainly based on gas chromatography (GC) and liquid chromatography (LC) coupled to mass spectrometry (MS). Another possibility is using chemosensors. Chemical sensors are miniaturised devices, consisting of a signalling unit and a binding unit, which deliver real-time information in the presence of a specific emerging contaminant in soil, water, or other environmental samples. [1]

At the European level, efforts are being done to provide data about surface and groundwater status, especially with the project project HOVER (Hydrogeological processes and Geological settings over Europe) which aims at controlling both natural and polluted groundwater quality across Europe. [6]

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Regarding PFAS, they are difficult to be totally avoided. Using PFAS free personal care products and cooking materials, and avoiding direct contact with PFAS containing products, helps to reduce exposure and the release into water. Several European countries have been active in monitoring PFAS in environmental media as well as in humans and products. Some countries have set national limit values for water and soil. Precautionary approaches to managing PFAS are being explored; this includes the organisation of PFAS in groups based on toxicity or chemical similarities.

School Laboratory Spectrophotometer, Pic by Saverio Romeo

The best strategy to be adopted is trying to reduce the production and use of PFAS. This is what Europe is trying to achieve. The Stockholm Convention and the REACH Regulation both relate also to PFAS and other ECCs. The Stockholm Convention is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, called POPs, Persistent Organic Pollutants, [7] of which PFAS are a part. REACH is a regulation of the European Union adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals.

In the long run, the most hazardous substances should be substituted with less dangerous ones. [8] The approach of the circular economy, where products are designed to be safe (and circular) from the start, is extremely important.

In Waste water treatment plants, organic content in waste is oxidised by microorganisms, but these types of plants are not effective in reducing newer contaminants, as in the case of EPs.

For EPs, it is necessary to go for new and advanced methods: ozonization, photodegradation, biodegradation. These can also be combined in a traditional activated sludges plant, but with the disadvantage of operational and construction cost.

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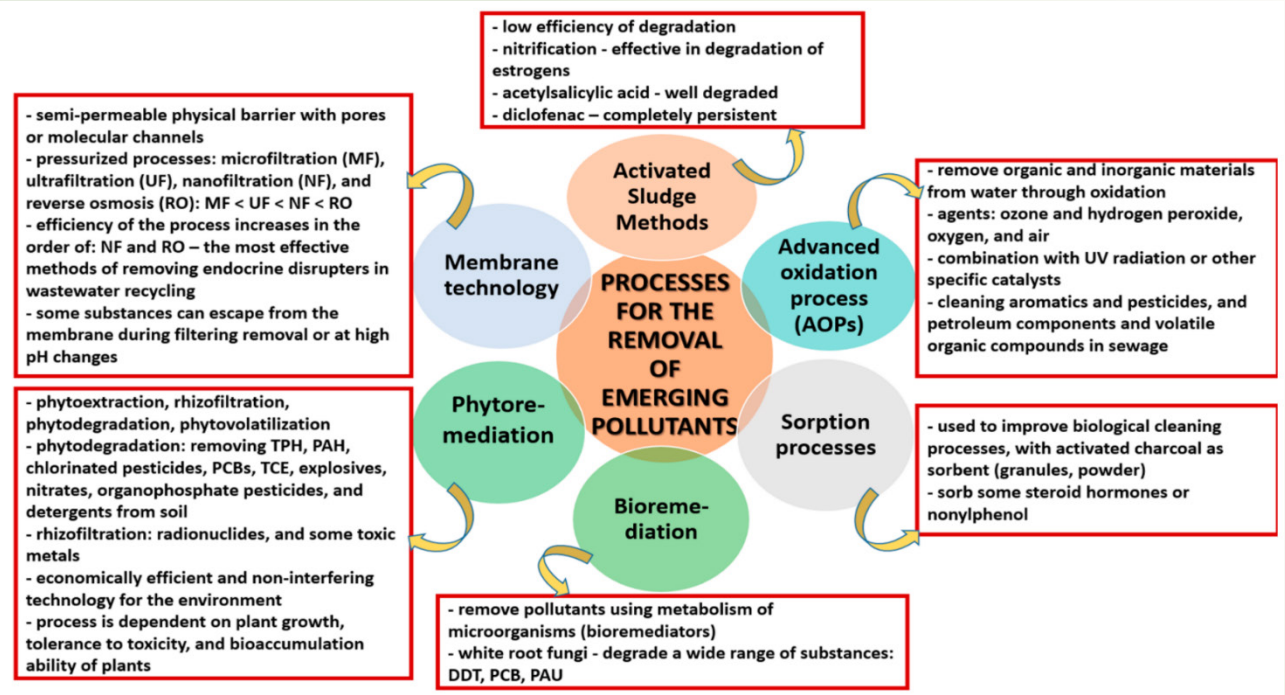

Picture from Occurrence and Fate of Emerging Pollutants in Water Environment and Options for Their Removal, BY Ionela Cătălina Vasilachi, Dana Mihaela Asiminicesei, Daniela Ionela Fertu, Maria Gavrilescu; Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/)

One of the treatments that are promising in removing EP is Constructed Wetlands (CWs). A Constructed Wetland (CW) is an artificial wetland to treat wastewater. It is interesting because it can be used both as primary and secondary treatment, which are the same phases that undergo in a traditional treatment plant, and also for the tertiary treatment, that is a more advanced phase that is used to increase the efficiency. [5]

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ALTERNATIVES TO PFAS

EBP Supply Solutions

	GREEN ALTERNATIVES						OTHER ALTERNATIVES		
									
MATERIAL	**ALUMINUM**	**PET**	**BAMBOO/PALM LEAF**	**POLYPROPYLENE**	**CLEAR PLA**	**PLA COATED PAPER**	**POLY COATED PAPER**	**OPS**	**STYROFOAM**
OVERVIEW	Durable metal resistant to grease and oils while maintaining food's true flavor	Polyethylene Terephalate, or PET is a clear plastic that is the most accepted recyclable plastic in the USA	Bamboo/Palm Leaf is a rapidly renewable resource which can be reusable and/or composted	Microwavable black or white containers in square, rectangle, round and oval shapes. Leak resistant, stackable and dishwasher safe	Polylactic Acid is a fully-renewable resource extracted from corn	Polylactic Acid that is created by combining paper with plant-based materials, rather than petroleum	Paper coated with Polyethylene by an extrusion coating process which provides moisture and grease resistance	OPS or Oriented Polystyrene is a durable clear of colored plastic suitable for takeout	Styrofoam, or extruded polystyrene foam, is a versatile material with good temperature insulation properties
GREEN CONTENT	▸ None	▸ Post Consumer	▸ Renewable Resource	▸ None	▸ Renewable Resource	▸ Renewable Resource	▸ None	▸ None	▸ None
PRODUCTS	▸ Containers ▸ Foil	▸ Cups ▸ Containers	▸ Containers ▸ Plates ▸ Bowls ▸ Trays ▸ Cutlery	▸ Containers	▸ Cups ▸ Containers ▸ Cutlery	▸ Cups ▸ Containers	▸ Cups ▸ Containers ▸ Plates ▸ Bowls	▸ Containers	▸ Cups ▸ Containers ▸ Plates ▸ Bowls ▸ Trays
BEST FOR	▸ Hot Items ▸ Cold Items	▸ Cold Items	▸ Hot Items ▸ Cold Items	▸ Hot Items ▸ Cold Items	▸ Cold Items	▸ Hot Items ▸ Cold Items	▸ Hot Items ▸ Cold Items	▸ Cold Items	▸ Hot Items ▸ Cold Items
FREEZING POINT	-20 °F	-20 °F	20 °F	0 °F	32 °F	32 °F	0 °F	20 °F	0 °F
DISTORTION POINT	400 °F	120 °F	250 °F	250 °F	120 °F	185 °F	180 °F	180 °F	180 °F
END-OF-LIFE OPTIONS	▸ Recyclable	▸ Recyclable	▸ Compostable ▸ Reusable	▸ Recyclable ▸ Reusable	▸ Compostable ▸ Reusable	▸ Compostable	▸ Landfill ▸ Incinerator	▸ Landfill ▸ Incinerator	▸ Landfill ▸ Incinerator
END-OF-LIFE RECOMMENDATION	Recycle wherever Aluminum is collected	Recycle where #1 is collected	Compost at a commercial facility	Recycle where #5 is collected	Compost at a commercial facility	Compost at a commercial facility	Incinerator	Incinerator	Incinerator

PFAS is contained in popular Bagasse and Molded Fiber compostable products, switching away from this while maintaining your green image can be challenging. The experts at EBP can help guide your transition with ease.

Have an initial discussion with an EBP foodservice specialist:
800.972.9622

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CONCLUSIONS

EOCs have been detected in surface waters around the world. Monitoring all these compounds, their concentrations in water bodies and their effect on humans, plants and animals, is already challenging, so removing them from the surface and/or groundwaters, is even more difficult.

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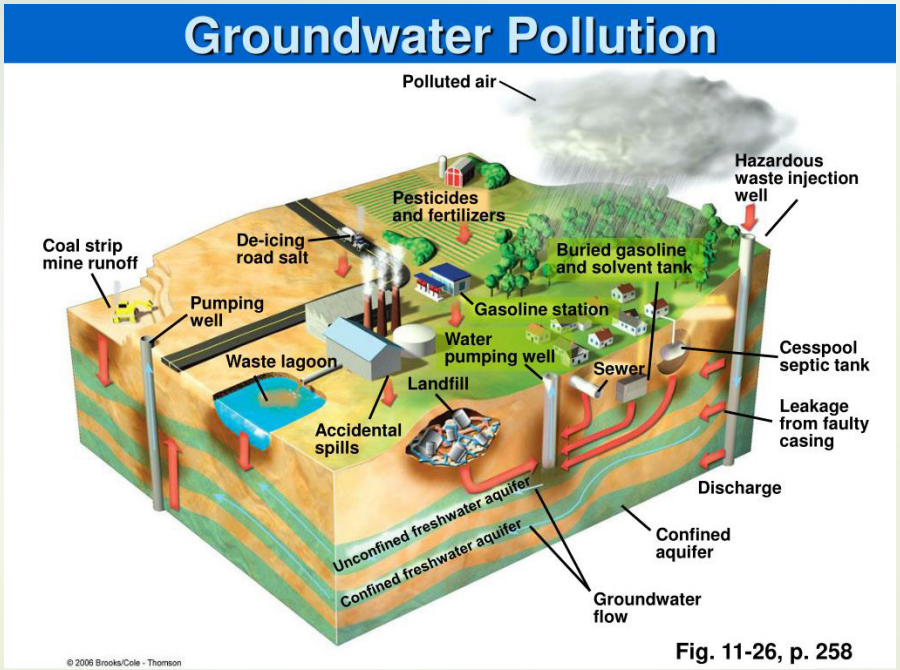

Groundwater pollution: https://www.slideserve.com/afia/water-and-water-pollution#

Some of these pollutants are used in a wide variety of consumer and industrial products, like PFAS.

They are, or degrade to, persistent chemicals that accumulate in humans, animals and the environment.

People who are mostly at risk are those exposed to high levels of PFAS and vulnerable population groups such as children and elderly people.

Obviously, it is not easy for citizens to completely avoid the exposure to PFAS but, using products such as PFAS-free personal care or cooking materials from the green labels may help. There are some consumer organisations and national institutions like the Danish EPA, German EPA and Swedish KEMI, that can guide us to find alternative products that are PFAS-free. In Europe several countries have been active in monitoring PFAS.

Some of them have set national limit values for water and soil, for textiles and for food contact materials. Many of them set a drinking water limit for specific PFAS. With more than 4,700 known PFAS, studying each substance's risk assessments one by one would be an extremely lengthy and resource-intensive process.

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As a result, complementary and precautionary approaches to managing PFAS are being explored. One of these may be the regulation of PFAS as a class, or as subgroups, based on toxicity or chemical similarities. Trying to reduce the production and use of EOC should be the first option to avoid the risks associated with them.

The use of pesticides, for example, can be avoided if we transit from intensive agriculture to organic, sustainable and smart agriculture. In the long run the advantages of organic farming are greater than the loss in the production of crops. Hazardous substances use should be minimised and substituted with less dangerous ones. New products should be safe and circular by design. Removal of EOCs cannot be achieved with traditional wastewater treatment plants and traditional methods, so it is necessary to adopt new advanced techniques to treat all these new challenging pollutants.

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