Business in the Community
The Prince's Responsible Business Network

HRH The Prince of Wales
Royal Founding Patron

Report

OPTIMISING BIORESOURCES: REDUCING WATER POLLUTION

June 2023

Reducing Chemical and Plastic Pollution of Wastewater

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Reducing Chemical and Plastic Pollution of Wastewater

Business in the Community's (BITC) network is leading the charge towards a thriving Net Zero economy, where both people and nature flourish. Through collaborative value chain sprints, BITC supports its members in tackling shared challenges head-on.

In this case, our network is driven by the urgent need to combat water and soil pollution, optimize bioresource utilization amidst rising fertilizer costs and reduce carbon emissions.[i]

Our current challenge is minimizing contaminants in wastewater/sewage systems, allowing the valuable materials in bioresources to be safely returned to the land, and reducing the pollution of effluent.

The substances polluting wastewater come from diverse sources, ranging from microfibers in everyday clothing to heavy metals from vehicle brakes and even pharmaceuticals. That is why this report is essential for all our members—it sheds light on an issue that affects us all.

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HRH THE PRINCE OF WALES ROYAL FOUNDING PATRON

Business in the Community
WWW.BITC.ORG.UK
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FOREWORD

The 21st Century has come with the dual challenge of safeguarding the environment and maintaining living standards. We must reduce carbon emissions from production and direct energy usage, manage our waste and avoid pollution of precious natural resources. At the same time, we need to manage inflationary pressures including increasing resource prices.

Effective action requires a willingness to address systems rather than work in silos: dialogue and discussion by interconnected businesses as well as with policy-makers. Practical mechanisms are required to work together to solve problems. This is where BITC comes in. As a network of businesses spearheading change, we can solve shared challenges and identify opportunities for innovation together. It has been an exciting journey, bringing people together to work on this problem. Many of those involved said they enjoyed the experience.

What is the key issue we have addressed here? Essentially, the accumulation of chemicals and microparticles in wastewater affects the value of precious biowastes, whilst also adding to the pollution of water bodies. These biowastes are an important source of bioresources needed for the food system.

Microplastics that are too fine to be removed through wastewater treatment processes end up in inland waters like lakes and rivers and in sewage sludge used to replenish soils. Micro-particles from tyres, some of which are plastic but also contain a range of chemicals, wash into our treated sewage sludge (biosolids).

Research from the University of Bangor found microplastic pollution levels ranging from over 1,000 pieces of plastic per litre in the River Tame in Greater Manchester to 2.4 pieces per litre in Loch Lomond. Chemicals such as triclosan from disinfectants also end up in our water supplyii.

If we were to shift to incinerating wastes rather than completing the circle and utilising them, we would be adopting the most expensive option for dealing with this waste, which is likely to be in excess of £120 per tonne, which would increase the costs of wastewater treatment considerably. This is likely to be more than double the cost of conventional wastewater treatment[iii].

At a time when water companies need to upgrade the sewerage network to increase resilience to heavy rainfall, to reduce sewage discharges into rivers, adding extra funding pressure is highly problematic. Putting all these costs on the end consumer through higher bills will further increase the cost of living.

Considering the complexity of this challenge and what is at stake, success requires all our collective ingenuity. It requires informed decisions, especially for corporate buyers of products to influence the market. Procurement makes a difference: for example, those with large fleets can ensure the tyres used are of the lowest toxicity. A study by Emission Analytics shows the least toxic tyres are 85% less toxic than the worst. Corporate buyers can use their purchasing power to reward those who reduce those emissions.

We focus on business action but recognise that government and regulators can take action to support businesses in their endeavours and create a level playing field.

Because of the importance of bioresources for our food systems, we regard this as potentially the first of several sprints relating to the use of biowastes. Our aim is to encourage and support action, surfacing the problems that need to be addressed and finding solutions collectively.

Maya de Souza, Circular Economy Director at BITC

> BITC's vision is for its members to spearhead ambitious, transformative action to achieve a Net Zero (Carbon), climate-resilient economy where people and nature thrive. We bring our members together to address shared challenges through a process of collaborative value chain sprints.

KEY FACTS AND FIGURES

- 12 million tonnes of wastewater are processed each day in the UK[iv]
- 3.5 million tonnes per annum of biosolids are applied to 150,000 hectares of land every year[v]
- This resource has a value of £60million per year[vi]
- 1,000 pieces of plastic per litre found in the River Tame in Greater Manchester and 2.4 pieces per litre in Loch Lomond[vii]
- 171 trillion microplastic particles floating in our oceans[viii]
- Pollution from tyre wear can be 1,000 times worse than what comes out of a car's exhaust[ix]
- Cost of fertilisers: 80% increase in 2021 and further increase in 2022[x]. There is a high risk of malnutrition in poorer countries if fertiliser prices stay high
- Wastewater-related emissions are roughly 20% of waste emissions in the UK[1]

THE CONTEXT

Biowastes - valuable resources

Biowastes have an important role to play in regenerative agricultural systems. These wastes are valuable resources which return organic matter to the soil. They also contain nutrients, such as phosphorus, which is an increasingly scarce resource in its primary form. It is obtained from a small number of countries but can be sourced from wastewater.

Waste-derived bioresources come from post-consumer food waste, food processing and agricultural waste, and treated sewage sludge called biosolids.

A circular approach - utilising these wastes as a valuable resource, has been in play for many generations. This would initially have involved spreading untreated sludge to land. Currently, this mostly involves spreading digestate to land. This is sludge that has been treated by Anaerobic Digestion (AD) which generates methane, used as a fuel, while also removing harmful bacteria.

Applying biowastes to soil has other benefits including increasing the water-holding capacity of soils, and also reducing flood risk.

The emerging challenge

The increasing amount of chemicals and heavy metals in wastewater systems is becoming a pressing issue. This threatens the viability of the circular approach. UK Water Industry Research (UKWIR) in its recent reports lists metals, fire retardants and biocides, hydrocarbons including oil leaks and lubricants, pharmaceuticals, hormones and personal care products, as having the potential to be present in both untreated and treated effluent[xi].

The challenge posed by the contamination of wastewater – biosolids and effluent released into the water, is the focus of this initiative.

This BITC initiative complements recent and ongoing work in the bioresources field, namely the Chemicals Investigation Programme (CIP)[xii] commissioned by UKWIR and the National Bioresources Strategy developed by the Chartered Institution of Water and Environmental Management (CIWEM) with the support of Atkins[xiii].

In the past, the priority of the CIP (CIP 1 and CIP 2) was understanding how chemicals entered water streams following wastewater treatment. CIP 2 included trialling technology to reduce chemicals within water following treatment across 600 water treatment sites. These two CIPs built a quantified picture to enable regulation in response to risks from chemical leakage, and for appropriate and justifiable remedial action to be taken.

Leading up to the CIP 3 reports published in March 2023[xiv], UKWIR investigated a much wider range of contaminants within wastewater, including microplastics, and anti-microbial resistance, and tested these contaminants drawing out emerging concerns and future challenges.

CIP 3 shows[xv] that chemicals are a problem in relation to the wastewater system. Seven out of a total of 32 substances exceeded their Environmental Quality Standards (EQS) and respective Predicted No-Effect Concentrations (PNEC) values. Examples included, a chemical used in plastic bottle production and a fire retardant[xvi].

The outcomes of investigations into microplastics show high removal rates from the final effluent: 99% by number and 99.5% by mass of microplastics, observed across all Waste Water Treatment Works[xvii]. This results in materials being transferred to sludge and consequently biosolids. Atkins concludes that because of the risk of transferring these substances to the soil, there is a strong argument for source control of microplastics, reducing the amount in wastewater.

The current legislative framework

Since 1989, human health and safety from pathogens have been protected by controls on spreading sewage sludge, in line with the

European Union (EU) Sludge Directive (87/278/EEC)[xviii]. This sets limits on the amount of sludge spread, the periods in the year when this is permitted, and reporting requirements. UK law also incorporates the European Commission (EC) Urban Wastewater Treatment Directive[xix], Nitrates Directive[xx] and other requirements.

Several voluntary schemes add to the safe application of these wastes. The UK's Biosolids Assurance Scheme (UKAS) sets out best practice for agricultural use coupled with independent UKAS-accredited auditing.

To date, the legislative framework has not focused on limiting contamination at the source.

However, because of increasing chemical and microparticle content in wastewater treatment works, EU and UK legislative frameworks are being reviewed. Alternative practices are being promoted in some countries. For example, in Switzerland, the use of sludge as a fertiliser is banned and incineration methods have been adopted[xxi]. This may be seen as a hazard-based approach to policy rather than an impact-focused approach considering the negative consequences for soil quality and carbon emissions.

This approach to chemicals taken by some European countries can be contrasted with that in the USA, Australia, and Canada. Currently, there are fewer limitations in these countries, other than in a few states, on what can be done with biosolids. They use a matrix of product quality criteria. Those with the highest quality specifications have unrestricted use[xxii].

Recent developments at an EU level show emerging thinking around the polluter pays principle[xxiii]. The principle is to ensure that those who produce and sell the contaminants bear, at least, a share of the costs. This principle is now embedded in the UK's legal framework through the Environmental Principles introduced by the Environment Act 2021[xxiv].

Having left the EU, Great Britain has the flexibility to determine how best to tackle this problem. The EU, Switzerland, US, and Australian approaches are all relevant for this consideration.

With increasing circular ambitions, driven by resource costs as well as pollution, policy and regulatory frameworks may require a change to support an effective circular market.

Use of procurement as a tool

This report is also part of our work on the Interreg ProCirc project which seeks to scale up the use of demand-side to embed and drive change. We have explored how procurement may help drive change.

There is potential to have more participants in the overall sludge market, meaning greater recognition of value. In anticipation of this, the Water Services Regulation Authority (Ofwat) is promoting sludge trading and seeking to encourage the wider development of the market.

We also explored the potential for purchasing power to be used to shape the market – and encourage the use of less toxic, degradable, and easy-to-remove materials.

It is clear that demand-pull is an important part of the picture in terms of circularity in both these ways.

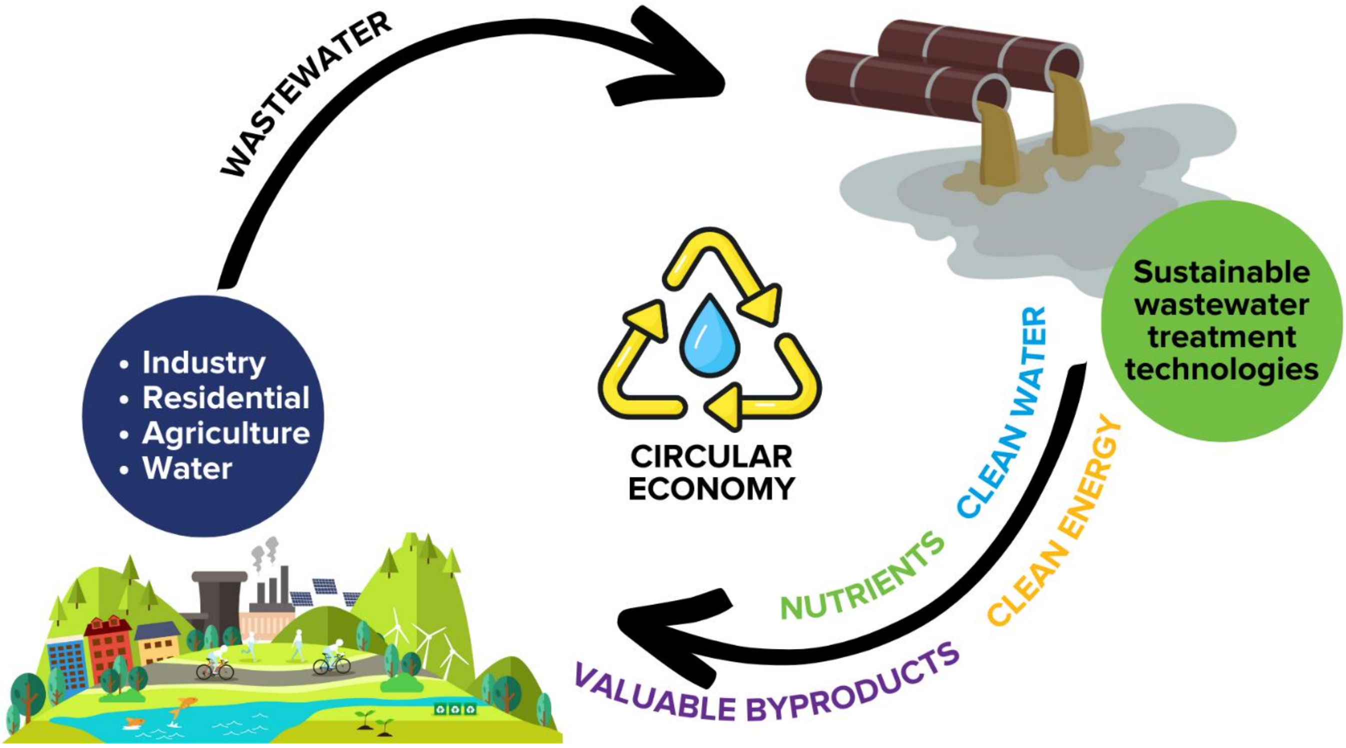


Figure 1: Biosolids Value Chain

The biosolids value chain, shown in Figure 1, can be seen as part of the food value chain. It is impacted by other sectors. It includes wastewater treatment, sludge handling, sludge treatment, product recovery, and the use of materials.

METHODOLOGY

We invited a number of companies operating along the biowastes part of the food value chain to a set of four workshops. This was to agree on the problem, co-create solutions, and identify potential actions by different actors.

Companies invited included: retailers of household products, pharmaceutical companies, laundry/washing companies, recycling companies, plastic manufacturers, companies that own fleets, water and sewage companies, and start-ups working on potential solutions.

Our approach was to provide a safe space for businesses to discuss and find solutions to this shared challenge.

Through these workshops, we facilitated discussions between businesses whose operations or products produce or release contaminants and those who manage and treat waste, informed by academics, policymakers, regulators, and trade associations.

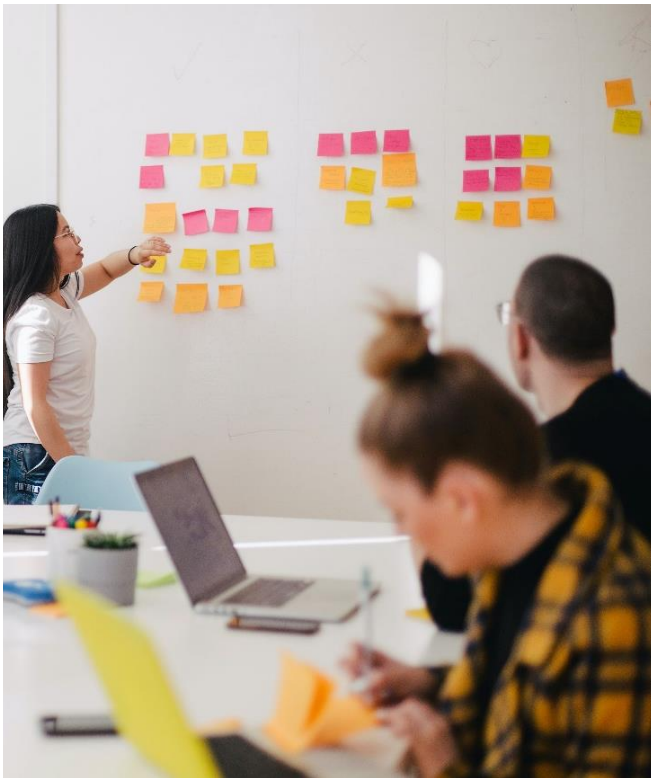
The first workshop, held in February 2023, agreed on a problem statement with stakeholders, with varying and sometimes contradicting business interests. This workshop was informed by a presentation by Professor Sakrabani, Associate Professor in Soil Chemistry at Cranfield University. He explained the challenge regarding optimising the use of biowastes. The discussion was also informed by presentations from senior Environment Agency officials. They spoke about the current regulatory and enforcement challenges and gave us a glimpse into the future of biosolids regulation.

The second and third workshops helped draw out the opportunities and challenges upstream and downstream in limiting soil and water contamination, i.e., the complexity of removing micro-particles at the treatment stage as well as in removing chemicals at the production stage.

These two workshops were co-creation sessions exploring the opportunities of using alternative products, green chemistry approaches, and complementary products to increase control over the source of contaminants. The second workshop focused on microfibre contamination engaging those who make and sell washing machines as well as laundry companies. The third concentrated on microparticle and chemical contamination from road vehicles. Companies who ran fleets and an expert on break and tyre emissions were also in attendance.

As well as these workshops, interviews were held with businesses from relevant sectors such as car manufacturers, pharmaceuticals, companies using and selling chemicals, and household goods retailers. These interviews have allowed for the impacts of activities and actions already underway to be better understood to inform the findings.

The final workshop was held in the BITC offices in Central London. Participants reviewed the preliminary findings and debated actions for business as well as measures to support business actions.



OUR PROBLEM STATEMENT: FINDINGS

The current sludge-to-land system: benefits

The current sludge-to-land system means that valuable nutrients, such as nitrogen, phosphorus, potassium, sulphur and organic matter that improves soil health are returned to agricultural land. This circular system leveraging the value of biosolids could be compromised by the level of contaminants released into wastewater systems.

Optimising the nutrient value from wastewater is particularly important considering that phosphorus is a finite resource. In the UK, 35,000 tonnes of phosphates from biosolids are used per annum with a financial value of £25 million[xxv]. In 2022, only about 15% of the phosphorus in sewage was recovered around the world. This presents a clear circular market opportunity for more phosphates to be recovered and transferred to the land in a bioavailable form (though the problems from over-application need to be taken on board).

In 2019, 80% of UK sewage sludge was applied to land[xxvi]. If this material were to be incinerated this would mean a loss of a substantial amount of organic matter to the soils, roughly 750,000 tonnes a year, as 3.5 million tonnes of biosolids are returned to the land each year[xxvii].

As a large proportion of agricultural soils are significantly degraded[xxviii] through intensive farming practices that have reduced soil organic matter, replenishing this with biosolids is important. Increasing soil organic matter improves soil structure and as a result, improves drainage of heavy soils, and increases the water-holding capacity and nutrient retention of light soils, as well as reducing flood risk. In contrast, mineral or synthetic fertilisers do not contribute to soil structure.

The priority of increasing soil organic matter aligns with the Department for Environment, Food and Rural Affairs (DEFRA) existing Nutrient Management Programme that outlines the benefits of managing nutrients to reduce run off, as soil organic matter enables greater percolation of water into aquifers.

The social importance of utilising secondary resources is even more evident in the context of rising fertiliser prices. In 2021, the mean price of nitrogen fertiliser in the UK increased from £281 to £785 per tonne[xxix].

From a carbon emissions standpoint, over-reliance on synthetic fertilisers is problematic. 48% of the global population is fed with the assistance of synthetic fertilisers, products made by the petrochemical industry[xxx]. Looking at Project Drawdown's set of top climate solutions for today[xxxi], both the conversion of organic waste to soil carbon through regenerative agriculture, as well as efficient nutrient management, are in its top 20 solutions to limit global warming to 1.5 ^{0}C. So big shifts are needed here in relation to fertiliser usage. Reducing our supply of biowastes goes in the wrong direction.

Jacobs quantified the contribution to net zero ambitions with the biosolids-to-land approach. Its analysis suggests applying biosolids to land reduces water and sewage company industry carbon emissions by approximately 10-20%[xxxii].

Risks from contamination

The circular sludge-to-land system is at risk from the accumulation of substances of concern:

a) microfibres from textiles like clothes, furniture, hospitality linen, etc; some of which will be plastics i.e., from synthetic clothing

b) microplastics from plastic bags, bottles, tyres, etc.

c) heavy metals from tyres and brakes, as well as lubricants and oil

d) other high-impact products, Per- and Polyfluorinated Substances (PFAS) also known as forever chemicals which are found on non-stick frying pans, waterproof clothing, and;

e) fire retardants like hexabromocyclododecane (HBCDD) are found in some products.

Microfibres, other microparticles, and PFAS are some of the best-known contaminants and have received press attention and have been subject to research over recent years. The limited research to date available to the water companies suggests that a small amount of PFAS remains in the sludge/biosolids with the majority transitioning to the effluent whereas the majority of the microplastics and other particles transition to the sludge/biosolids.

Forum for the Future estimate that pre-consumer textile manufacturing releases 0.12 million tonnes per year of synthetic microfibres into the environment[xxxiii]. The Guardian on the 'Scale of Forever Chemical Pollution'[xxxiv] and Chartered Insitute of Environmental Health have also highlighted tyres made from synthetic rubber. They are derived from crude oil and contain a number of toxic organic compounds. As tyres make contact with the road surface, they release tiny particles measuring less than 23 nanometres[xxxv] . But they are not the only problematic particles from vehicles.

A product can include multiple contaminants, for instance, curtains that shed microfibres could include fire retardant sectors.

Table 1 prepared with help from Cranfield University sets out other problematic contaminants:

Table 1

Antimony	Flame retardants in consumer electronics.
Tin	Organotin used in PVC stabilisers, catalysts for polyurethane foams and silicones.
Silver	Silver nanoparticles from clothing, cosmetics, and personal care products, because of their antibacterial properties
Rare earth elements	Platinum (Pt), Titanium (Ti) Lithium (Li).
Triclosan[xxxvi]	Antibacterial found in personal care products.

It is not only that contaminated biosolids may pose a problem for soils, but some water-soluble substances will end up in water bodies.

Potential Impacts

The fate of bioresource applications in the UK and the EU is currently being decided because of these contaminants. The Environment Agency maintains a priority-early warning system (PEWS) for contaminants and has identified PFAS chemicals as a key concern but there is limited data on chemicals in biosolids. The composition of solids varies both geographically and temporally across England and Wales. Some substances were not detected in any samples, while many were found across all sites[xxxvii].

The primary pathway to get biowastes from the food value chain to agriculture is by using AD and applying the digestate created to land. AD is a treatment process for sewage sludge that removes harmful substances within the biosolids and produces biogas, a renewable fuel source made up of methane and carbon dioxide, 66% of the UK's sludge is treated by anaerobic digestion[xxxviii].

If contamination is not moderated at the source, water and sewage companies will need to invest in sophisticated treatments such as thermal treatment technologies including incineration, as at present there is no known means of extracting some substances at present.

Extracting substances that can be removed at the wastewater treatment stage presents challenges, as investment costs in technologies and infrastructure for incineration would be passed onto the water consumer.

If substances cannot be removed at this stage, one option is incinerating the waste. According to research by Manchester University[xxxix], this is the most expensive option. The costs of incineration are likely to be in excess of £120 per tonne, which is likely to be more than double the costs of conventional wastewater treatment[xl]. This is based on the costs of incinerating dry matter, at present being £54 per tonne but incinerating wet waste is significantly more expensive, as it is only 25-30% dry solids. The costs of expanding incineration facilities substantially and fitting such systems with carbon capture and storage in the future also need to be taken into account.

A shift to incineration would mean emissions from water companies increase. These are also arguably Scope 3 emissions of those sectors that sell material that contaminate bioresources.

Additional investment would likely be passed onto consumers in higher bills, and this would compete with the need for water companies to invest in infrastructure to reduce stormwater discharges into rivers.

There appear to be a number of future scenarios or approaches that can be adopted. The benefits and risks of each option are presented in Table 2:

Table 2

Scenario	Benefits & Risks
Minimal change (current position)	Environment regulatory changes lead to minor improvements. Risks: contaminated bioresources lead to soil and water contamination
Maximum recycling (advanced anaerobic digestion)	Circular economy is enabled by regulation, so a wide variety of products from sewage and sludge can reach many markets. Risks: quality and contaminant composition of new products, market demand and regulatory requirements
Cautious recovery (advanced thermal treatment tech)	Regulations constrain the part sewage and sludge can play in a circular economy as sewage origins and public perception prevent full access to product status and markets. Risks: technologies need further development, and the fate of contaminants is unknown.
Precautionary principle – Employing preventative measures reducing the usage of persistent chemicals or microfibres/particles which do not degrade in a reasonable period or ensuring they do not enter the wastewater system.	Leaving the environment in a better state than we found it and addressing fear of contaminants in sludge. Benefits: externalities are in effect internalised Risks: chemical industry, textile industry, tyre manufacturers, and washing machine manufacturers incur costs

The problems presented raises questions about whether businesses have the available technologies, from ensuring that chemicals degrade safely, or in removing contaminants through wastewater treatment.

Another question is who should bear the cost of change? Should the polluter-pay principle be implemented to prevent substances from entering wastewater or in removing them through wastewater treatment?

IMPLICATIONS FOR BUSINESSES, REGULATORS AND POLICY-MAKERS

General Principles

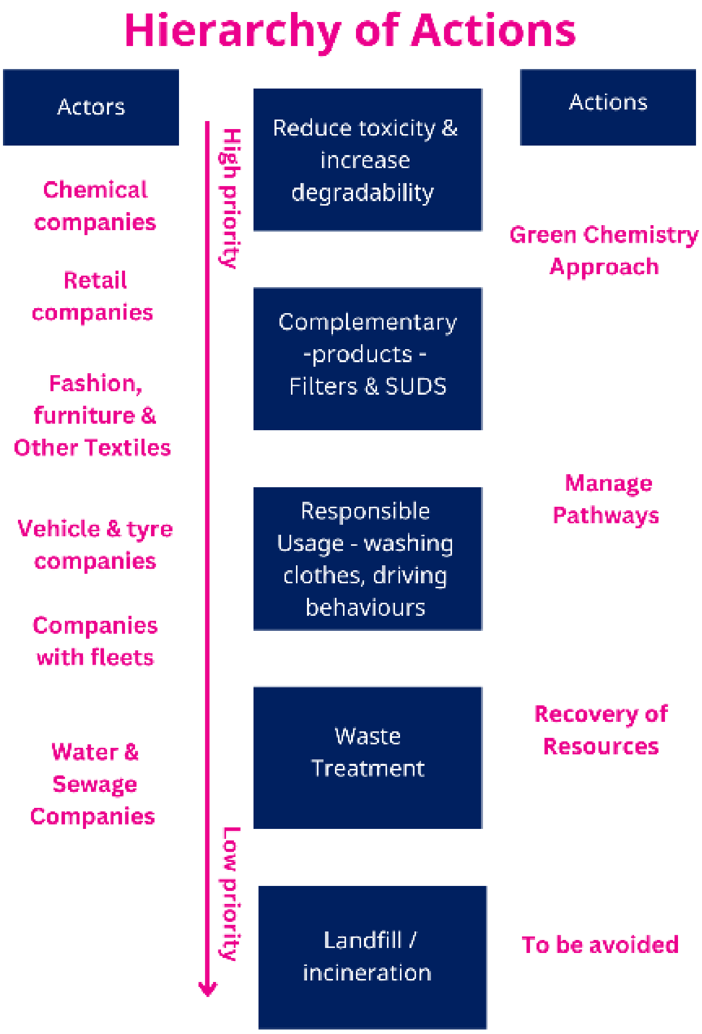
The implications that we have drawn from the problem are laid out in two sections. Firstly, in relation to the overarching issue of contamination. Secondly, actions businesses can take to alleviate soil and water pollution in relation to specific pollutants.

The importance of a set of principles to address these issues emerged. These take account of a set of societal goals including carbon reduction, impact on pollution and cost, as well as existing legal principles, such as the polluter pays principle.

The ideas that emerged are as follows:

a) a clear Hierarchy of Actions (HoA), as shown in Figure 2, would help create a new norm, guiding action by all concerned, and encouraging investment in the right direction. The hierarchy developed seeks to account for multiple considerations including climate change and cost. An agreed hierarchy should help avoid unnecessary investment, for example, in large-scale incineration which is inconsistent with climate and agricultural goals. The hierarchy shown is aligned with the waste hierarchy: prevention lies at the top and disposal at the bottom.

Figure 2: Hierarchy of Actions (HoA)



b) the importance of green chemistry in tackling complex barriers to the circular economy. We use the term green chemistry here as a catch-all for the design (or redesign) of products and materials, for example, to allow degradability as well as manufacturing processes to reduce their negative environmental impacts[xli].

Green chemistry principles are central to source control of contamination and Research and Development (R&D) units within businesses can invest in the transition to less harmful materials. This step can be supplemented by action to block pathways to receptors.

c) companies that source chemicals, products, fleets and other relevant products and services have a role to play in driving change through procurement. The provision of information and labelling is needed to help procurers make informed decisions. For example, the evidence suggests that some tyres are much more problematic than others, which end users, including those who buy or use fleets, may not otherwise recognise.

d) businesses need to be aware of unintended consequences and find solutions that take on board multiple objectives. Issues that have emerged included the weight of electric vehicles being greater than traditional combustion engine vehicles resulting in increased contamination from brake and tyre particulates. Mitigating action is needed to deal with this problem, potentially by those responsible for highways. Another issue is that interactions between chemicals can create more toxic daughter compounds.

e) greater emphasis on the recovery of materials not just the removal of problematic materials. The focus on removal, not recovery, has not supported a circular approach where full use is made of available resources. We have already noted that phosphates are a scarce resource. For these, there are no recovery targets in place. Communicating their worth through policy measures would give clear direction. Germany's sludge regulations require a recovery rate of 80% in relation to the sewage plant's phosphorus input[xlii]. This may also help reduce the release of phosphates into water bodies.

f) research to understand the true impacts of different materials and substances, and how to best manage these risks. It is important to move beyond a focus on particle size (e.g., PM10s, PM2.5s), to the actual properties of substances as they vary in their toxicity.

Proposed hierarchy

The hierarchy starts with green chemistry principles of designing materials without toxic substances or shifting away from manufacturing processes that produce wastes harmful to the environment. It is followed by increasing the biodegradability of those substances into harmless substances. These aspects of the value chain can be seen as the responsibility of businesses that make and use forever chemicals, a group of chemicals which have high lifetimes in the environment known as the PFAS family. R&D can support the use of better materials.

The second step of the hierarchy beyond reducing toxicity and increasing degradability is making use of approaches to block the flow of pollutants to the wastewater system. Washing machine filters and sustainable urban drainage systems are of benefit here. These sustainable drainage systems have the added benefit of supporting the replenishment of groundwater. The third step is responsible usage, for example, avoiding unnecessary washing of clothes is important.

The fourth step relates to wastewater treatment systems that enable the recovery of these particles and other substances. These materials often have value, and some are recoverable. However, the recovery of some materials, like fine microplastics, is extremely difficult or impossible at present and at this stage of the cycle.

The fifth and least preferable step on the hierarchy is incineration. This will lead to additional carbon emissions and impacts on soil health.

There are implications for the wider value chain of this hierarchy. Upstream business innovation i.e., by the chemicals and materials industry can be supported and driven by corporate buyers and the end-user. These companies supported by their procurement teams can actively encourage investment in less toxic or degradable products, potentially bio-based. But this requires them to know the material difference between products.

It is important that policymakers also consider and explore ways of embedding this hierarchy.

Implications: specific contaminants

The following actions and measures to enable business action are presented in terms of specific contaminants: microfibres, microplastics, specific heavy metals and chemicals. Where possible, we have stated which actions can best be done by different businesses and teams within respective corporations.

1) Microfibres

Microfibres, by definition, are fibres finer than one denier and with a diameter of less than ten μm[xliii]. Distinctions are made between natural and synthetic fibres, with the former having higher biodegradable properties. Even natural fibres once dyed and treated, blended with other fibres and manufactured into finished goods, are not biodegradable[xliv]. Microfibres detach from almost all textiles such as furniture, soft furnishings, and clothing during use and through washing processes. Filters are now available that can be attached to washing machines which are designed not to be washed by the user, which would defeat the purpose.

- Implications

It is important that washing machines are sold with filters, either included within the design or complementary, with action by manufacturers and retailers of appliances. Customer behaviour should be anticipated and reflected in the design, backed by an education campaign on the correct use of these products. Continuing design and innovation are important to bring costs down. Certainty of the direction of travel should support investment and enable efficiencies from production at scale.

Clothing and appliance retailers could usefully explore ways to encourage customers to wash clothing less frequently.

Procurement teams in businesses which buy textiles should train their teams to apply due diligence in choosing materials and suppliers i.e., asking for material specifications and their impacts.

It is advisable for communication and marketing departments/ agencies to be cautious about making general claims regarding sustainability. The Competition and Markets Authority (CMA) has recently developed the Greens Claims Code which sets out six key points to check your environmental claims are genuinely green[xlv]. Further sector-specific guidance may support change.

France is addressing the challenge of microfibre contamination of water and soil with a new law to curb contamination of plastic microfibres, which states that by 2025 every new washing machine must have a filter that catches microfibres during washing[xlvi]. This is a good example of how governments can support business innovation.

2) Microparticles

Microparticles include microplastics and minuscule heavy metals. Microplastics are plastic particles generally smaller than 5mm but larger than one or 100 nm[xlvii]. Microparticles derive from multiple sources like tyres, personal care products, road markings, and city dust. Car tyres are a mix of rubbers, synthetic polymers, and molecules, and together with metals, they make up an estimated 5-10% of microplastics in the ocean[xlviii]. Particles of heavy metals also result from braking. There have been instances of progressive legislation to limit the amount of specific heavy metals in their manufacturing[xlix].

- Implications

It is important for tyre and car manufacturers to collaborate in finding ways to address the problem or at least communicate the material content and impact of their tyres.

Emissions Analytics, an independent testing house specialising in real-world emissions testing, found the least toxic tyre is 85% times less toxic than the worst, and the least toxic manufacturer 61% times less than the worst[l].

Procurement teams for companies with large fleets should take on board toxicity levels of different tyres in purchasing and leasing. Utilising databases such as International Material Data System (IMDS) and Generating Availability Data System (GADS) will help. Companies that own or lease fleets and have company cars can also ensure those driving vehicles are trained to do so appropriately. Behaviours such as harsh braking influence the amount of tyre and brake emissions.

Recycling and repurposing businesses should seek to understand the impacts of upcycling tyres and plastics such as into playgrounds. The benefits of reusing materials may be outweighed by the pollutant properties.

Investment in sustainable drainage systems to filter run-off is also important[li]. They need to be integrated into the management of highways as well as private roads and car parks.

There are opportunities to advance the current legislative landscape. Extended Producer Responsibility (EPR) policy could include mandatory material transparency or minimum standards for tyres.

Support could be provided to businesses to ensure innovative products in this field are not impeded by costly and lengthy processes.

3) Chemicals

Many of the key chemicals of interest lie within the PFAS family. There are over 5,000 such chemicals often known as forever chemicals due to their persistence in the environment and resistance to biodegradation[lii] and others such as fire retardants known as hexabromocyclododecane (HBCDD)[liii]

R&D and procurement teams within businesses that handle chemicals in their supply chain should support investment into alternative chemicals that are less harmful to the environment such as biodegradable flame retardants.

Researchers specialising in green chemistry have scoped potential opportunities for biodegradable polylactic acid with bio-based compounds such as cellulose, starch chitosan, alginates, and lignin as biodegradable carbonisation agents in flame retardants[liv].

Similarly, there is the potential to examine the biodegradation of PFAS through the application of new technologies[lv].

- Implications

Retail businesses are in a unique position to influence the brands they stock in shops. Some retail companies have prohibited Perfluorooctanesulfonic acid (PFOS) in their own brand products, which is one of the most concerning chemicals within the PFAS family. They should undertake due diligence for other brands which they sell in stores.

Businesses that handle and manufacture products containing chemicals should look to provide information to buyers enabling them to make informed decisions. Robust Ecolabels can help with this. The EU Ecolabel for household detergents[lvi] requires them to be composed of biodegradable surfactants and comply with a ban on Ethylenediaminetetraacetic acid (EDTA), and its salts, microplastics, and triclosan amongst other substances. The Nordic Swan label also sets similar standards[lvii].

For chemical contaminants, biodegradability is an important option, but clear standards are needed. This will be dependent on the substance. There is no need for a one-size-fits-all definition for biodegradability generally.

Ultimately when developing new biodegradable chemicals, several factors should be kept at the forefront of development: damage to health, environmental impact, and performance and economic efficiency.

Government action could support progressive business actions to phase out forever chemicals, by backing their moves with requirements that apply to all.

Regulators and policy-makers need to continue to collaborate to address new hazardous substances within the REACH Directive or its UK alternative. This is because unregistered chemicals go undetected even though they could be far more harmful.

UTILISING PURCHASING POWER TO SUPPORT CIRCULARITY

A theme that emerged from our process of engagement and discussion was the power of procurement to support this shift.

There are a number of ways this can be done which have been brought out in discussions:

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KEY PROCUREMENT RECOMMENDATIONS
Procurement teams in businesses which buy textiles should train their teams to apply due diligence in choosing materials and suppliers i.e., asking for material specifications and their impacts.
Procurement teams for companies with large fleets should take on board toxicity levels of different tyres in purchasing and leasing. Utilising databases such as IMDS and GADS will help. Companies that own or lease fleets and have company cars can also ensure those driving vehicles are trained to do so appropriately. Behaviours such as harsh braking influence the amount of tyres and brake emissions.
R&D and procurement teams within businesses that handle chemicals in their supply chain should urgently support investment into alternative chemicals that are less harmful to the environment such as biodegradable flame retardants.

This relates to the work BITC has been doing with ProCirc, funded by the EU Interreg programme, on driving forward circular procurement, i.e., procurement to support a shift to a more circular economy. This programme has created a series of tools that can be utilised by those responsible for buying and sourcing products, materials, and services as well. You can read more information here.

We see this report as adding an extra dimension to ProCirc's work. Instead of looking at how to buy products that can be, for example, reused, repaired, and recycled, it focusses on how procurement can be used to reduce the amount of harmful chemicals that enter the wastewater system, and therefore ensure that these wastes can be utilised at the highest value, i.e., as a resource.

CONCLUSIONS

A regenerative approach where valuable biosolids are used in a circular sludge-to-land approach is at risk because of the increase in contaminants in water and sewage systems. The actual risk, or a perception of risk, may lead to a shift to incineration, despite the benefit to agricultural land. Incineration will most likely increase carbon emissions and residues will need to be disposed of.

Our collaborative value chain sprint, involving our diverse membership, drew out the implications and explored solutions. The overarching insight is the benefit of a clear hierarchy of action. Preventing the use of pollutants that create a risk to the environment over time would be at the top. It could be achieved by following green chemistry principles including designing out hazardous elements or increasing their degradable properties. This, along with preventing these pollutants from entering the wastewater system, amounts to source control of contamination.

However, this will not always be possible and in some cases, the question will be about removal at the waste treatment stage and who will pay for this. Here, extended producer responsibility as a mechanism of sharing costs needs consideration.

A clear hierarchy will help steer businesses, especially if backed by policy-makers and regulatory policy.

Upstream business innovation can be supported by those who buy relevant products and services – whether leasing fleets, sourcing pharmaceuticals, or buying uniforms or laundry services. Information for end users and consumers through eco-labels or similar means can also support change.

The solutions in this report are focused on companies whose activities relate to biowastes but are also of relevance to regulators and policy-makers who can support the business community and help ensure a clear direction of travel and a level playing field.

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ANNEX: TECHNICAL TERMS

Anaerobic Digestion (AD)

Anaerobic Digestion (AD) is used as a treatment process for sewage sludge in the UK, with 66% of the UK's sludge being treated this way[lviii]. It is designed to reduce the volume of sludge and stabilise organic materials such that it has no health hazards or offensive odours[lix]. AD has three steps: thickening, digestion, and dewatering. Following these three stages of AD, the sludge is used as a soil fertiliser, conditioner or buried in sanitary landfills.

Advanced Anaerobic Digestion (AAD)

AD is inhibited by ammonia within sewage sludge, which increases the energy required to maintain AD[lx]. AAD adds an additional hydrolysis stage before digestion, which significantly increases organic material breakdown producing a greater conversion of organic matter into biogas, a 50% reduction in sewage sludge volumes and higher-quality biosolid fertilisers. Through AAD, sludge is reduced to 12% of its original volume, cutting the cost of transportation.

Biogas

The biogas produced from AD and AAD is classed as renewable and helps meets Britain's international climate change commitments. Additionally, AAD is energy self-sufficient which reduces operational costs to treat sewage sludge and improves the efficiency of sludge management.

Metals

The metals within sewage sludge and wastewater are valued at millions of US dollars per year[lxi], including chromium, mercury, lead, nickel and cadmium which can enter water streams from cleaning products, water treatment chemicals, cosmetics, and medications[lxii]. These metals are highly toxic to aquatic life and need to be removed, however current conventional technologies to remove these metals require large amounts of energy and produce a toxic sludge. There is ongoing research into recovering metals without toxic products such as biosystems using micro-organisms to recover the metals, however, this research is in the early stages.

If sludge is incinerated, it produces ash containing phosphorus and toxic metals, such as lead, nickel and cadmium. This ash is hard to dispose of due to the toxicity of these metals and the negative environmental consequences of phosphorus.

Organic and mineral fertilizers

Organic fertilisers originate from natural and renewable materials, such as composting vegetable and garden waste, using fish emulsions, or manure, whereas mineral fertilisers are synthetically made to be rich in nitrogen, potassium and phosphorus[lxiii]. Mineral fertilisers use a large amount of ammonia to supply nitrogen to plants and soil, this ammonia contributes to 1-2% of global carbon emissions[lxiv].

Organic fertilisers have fewer environmental risks as they are slow to release nutrients into the soil and improve the soil structure, drainage, and quality. Overusing mineral fertilisers results in more nutrients in the soil than plants can absorb, these nutrients run off into water streams and become broken down by microbes in the soil to release nitrogen oxide into the atmosphere[lxv]. Nitrous oxide is a potent greenhouse gas with a warming effect 300 times as much as carbon dioxide.

Microplastics

Organic fertilisers originating from sewage sludge or wastewater do contain microplastics, often from tyre particles, synthetic textile microfibres, food storage containers and previously from microbeads in cosmetics that have been banned since 2018[lxvi][lxvii]. Many microplastics enter waste streams through use, such as tyres shedding microplastics when driving and breaking in vehicles and textiles shedding microfibres during wear. There is little data on how these microplastics enter waste streams besides textiles being washed and microbeads in soaps, however, we know microplastics can travel far from their source.

Approximately 35% of microplastics in oceans are believed to originate from microfibres from washing synthetic textiles where these microfibres enter water streams[lxviii]. Microfibres are the most abundant microplastic in waste and freshwater, blocking the guts of and starving riverbed organisms and other sea creatures. Microplastics can be removed from wastewater by incineration of sewage sludge but this is expensive and prevents extraction of assets within wastewater such as nitrogen and phosphates.

Recent Defra-funded research project by the University of Plymouth, Newcastle University, Eunomia, and Kings College London found that tyre particles are a major direct source of microplastics into the environment[lxix]. These particles were shown to enter the environment through three routes examined by the study: released from wastewater effluent, direct release from roadside water drains, and air-based deposits within 50m of roadsides. In all these cases, tyre particles were entering the environment in substantially greater volumes than microfibres, with roadside water drains being the key route for tyre particles whilst air deposits were the key route for microfibres.

Nitrogen

Sewage sludge is rich in ammonia, a nitrogen-based substance. As such, nitrogen can be extracted from the sludge using the Haber Bosch process to produce nitrogen gas[lxx]. This nitrogen is used as fertiliser but must be converted back into ammonia to do so through the Haber process. Overusing mineral fertilisers results in more nutrients in the soil than plants can absorb, these nutrients run off into water streams and become broken down by microbes in the soil to release nitrogen oxide into the atmosphere[lxxi]. Nitrous oxide is a potent greenhouse gas with a warming effect 300 times as much as carbon dioxide.

PFAS and forever chemicals

PFAS are per-and-poly-fluoroalkyl substances, there are over 5,000 chemicals within the PFAS family which are known as forever chemicals due to their persistence in the environment and resistance to biodegradation[lxxii]. PFAS can occur as both polymers, long chains of repeating units, or non-polymers, singular units, with non-polymer PFAS being of more concern as they are more commonly detected in humans and the environment.

Some PFAS chemicals are banned or restricted in the UK[lxxiii] but PFAS are still widely used industrially and in households through cosmetics, car and floor polish, textile treatments, food packaging, frying pans, outdoor clothes and in shoes. As a result, they can enter waste streams through a multitude of routes. PFAS have been found in wastewater treatment plants, without treating water humans can be exposed to PFAS from wastewater, potable reuse, or bioaccumulation of PFAS into soil and food[lxxiv].

The two most concerning chemicals within the PFAS family are PFOS and PFOA which are both associated with adverse human and animal effects, as such they are both restricted in England and Wales by UK REACH and are being phased out of use. PFOS, perfluorooctanoic sulphonic acid, is directly linked to reproductive toxicity, immune effects, and kidney toxicity[lxxv] whilst PFOA is perfluorooctanoic acid is linked to kidney cancer, testicular cancer and high cholesterol[lxxvi].

Phosphates

Phosphates are important as fertilisers. Currently, 80% of phosphates used globally are non-renewable, natural phosphates[lxxvii] which are sourced from just a few countries.

Sewage sludge has a high concentration of phosphates that are renewable, and through hydrothermal, thermochemical, and adsorption methods we can achieve a greater than 95% recovery of phosphorus compounds. Extracted phosphates in organic compounds can be used as insecticides, plasticisers, and surfactants, whilst inorganic phosphates can be used as fertilisers. Incinerated sewage sludge ash cannot be used as fertiliser however research is being done to develop viable methods to recover phosphorus from the ash to produce fertilisers[lxxviii].

Phosphates can cause eutrophication, a process where algae blooms, blocking out sunlight in water habitats which kills fish and other aquatic organisms.

Sewage sludge

Sewage sludge is the slurry biproduct of wastewater treatment and is classed as either primary sludge from chemical precipitation or secondary sludge from activated waste biomass.

ENDNOTES

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[i] National Farmers Union, 2022
[ii] Ibid
[iii] Estimated by the Biosolids Assurance Scheme.
[iv] https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Waste.pdf p.6
[v] https://assuredbiosolids.co.uk/about-biosolids/#:~:text=Around%203.5%20million%20tonnes%20per,of%20the%20UK%27s%20agricultural%20land
[vi] Ibid
[vii] https://www.bangor.ac.uk/news/archive/microplastic-pollution-widespread-in-british-lakes-and-rivers-new-study-40043
[viii] https://www.microplasticsolutions.org/?gclid=Cj0KCQjwmN2iBhCrARIsAG_G2i4Qy2qkrR6hBh5_G5HhzGg6qxfVv8DTQ_y3GYHtBhxWFqO8U4f3DVEaAi4rEALw_wcB
[ix] https://www.emissionsanalytics.com/news/pollution-tyre-wear-worse-exhaust-emissions
[x] https://blogs.worldbank.org/opendata/fertilizer-prices-expected-remain-higher-longer
[xi] https://ukwir.org/sign-up-and-access-the-chemical-investigations-programme-data-access-portal
[xii] Ibid
[xiii] https://www.ciwem.org/policy-reports/towards-a-long-term-bioresources-strategy-for-england
[xiv] https://ukwir.org/cip3-information
[xv] Volume 5 on monitoring emerging concerns in wastewater treatment work (WWTS) influent, effluent, and sites in receiving watercourses both upstream and downstream)
[xvi] https://ukwir.org/the-national-chemical-investigations-programme-2020-2022-volume-5-substances-of-emerging-concern
[xvii] https://ukwir.org/the-national-chemical-investigations-programme-2020-2022-volume-2-investigations-into-the-fate-and-behaviour-of-microplastics-within-wastewater-treatment-works
[xviii] The Code of Practice for Agriculture Use of Sewage Sludge provides additional detail.
[xix] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01991L0271-20140101

[xx] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01991L0676-20081211

[xxi] https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-1673.html

[xxii] https://ukwir.org/reports/15-SL-13-5/145968/Exploring-attitudes-and-perceived-barriers-to-the-use--recycling-of-biodegradable-products-containing-sewage-sludge

[xxiii] https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_6281

[xxiv] https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted

[xxv] Biosolids Assurance Scheme

[xxvi] https://www.researchgate.net/figure/Sewage-sludge-recovery-routes-in-Europe-2_fig1_336891632

[xxvii] https://chemtrust.org/sewage-sludge-mcs/

[xxviii] https://www.fao.org/documents/card/en/c/CB1929EN

[xxix] National Farmers Union, 2022

[xxx] Cambridge https://www.cam.ac.uk/research/news/carbon-emissions-from-fertilisers-could-be-reduced-by-as-much-as-80-by-2050

[xxxi] https://drawdown.org/

[xxxii] https://assuredbiosolids.co.uk/wp-content/uploads/2021/12/UK-Water-Net-Zero-Quantifying-the-role-of-biosolids-to-land.pdf p.3

[xxxiii] https://www.forumforthefuture.org/investigating-opportunities-to-reduce-microfibre-pollution-from-the-fashion-industry

[xxxiv] https://www.theguardian.com/environment/2023/feb/23/revealed-scale-of-forever-chemical-pollution-across-uk-and-europe

[xxxv] Chartered Institute of Environmental Health

[xxxvi] https://pubmed.ncbi.nlm.nih.gov/22561896/

[xxxvii] https://ukwir.org/the-national-chemical-investigations-programme-2020-2022-volume-12-biosolids-report

[xxxviii] https://www.biogas-info.co.uk/about/faqs/

[xxxix] Life cycle costs of advanced treatment techniques for wastewater reuse and resource recovery from sewage sludge, University of Manchester, 2018, p.2.

[xl] Estimated by the Biosolids Assurance Scheme.

[xli] https://www.sciencedirect.com/science/article/abs/pii/B9780123864543010204

[xlii] New German Sludge Regulation

[xliii] https://link.springer.com/article/10.1007/s11356-019-06265-w#:~:text=Definition%20of%20microfiber%20pollutant,(Jerg%20and%20Baumann%201990).

[xliv] https://www.theguardian.com/fashion/2023/apr/24/fashion-greenwashing-glossary-part-two-what-do-biodegradable-closed-loop-and-degrowth-really-mean

[xlv] https://greenclaims.campaign.gov.uk/

[xlvi] https://www.oceancleanwash.org/2020/02/france-is-leading-the-fight-against-plastic-microfibers/#:~:text=As%20of%20January%202025%2C%20all,fight%20against%20plastic%20microfiber%20pollution

[xlvii] https://pubs.acs.org/doi/10.1021/acs.est.8b05297

[xlviii] https://ukwir.org/Sink-to-River---River-to-Tap---A-review-of-potential-risks-from-nano-particles-microplastics

[xlix] https://dtsc.ca.gov/scp/limiting-copper-in-brake-pads/#:~:text=On%20September%2027%2C%202010%2C%20Governor,More%20details%20available.

[l] Emissions Analytics (2023) Real World Tyre Degradation Particle VOC Analysis Benchmarking Database

[li] https://www.netregs.org.uk/environmental-topics/water/sustainable-drainage-systems-suds/filter-strips-and-filter-drains-in-sustainable-drainage-systems-suds/

[lii] https://www.dwi.gov.uk/pfas-and-forever-chemicals/

[liii] https://ukwir.org/urban-runoff-including-road-runoff-and-atmospheric-deposition-how-to-apportion-pollution-load-especially-chemicals-of-emerging-concern-19

[liv] [liv] https://www.mdpi.com/2218-273X/10/7/1038

[lv] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7817812/ microbial ecology (stable isotope probing and metagenomics)

[lvi] https://ec.europa.eu/environment/ecolabel/documents/HH%20file.pdf

[lvii] https://www.nordic-ecolabel.org/

[lviii] https://www.biogas-info.co.uk/about/faqs/

[lix] https://www.britannica.com/technology/wastewater-treatment/Sludge-treatment-and-disposal

[lx] https://www.sciencedirect.com/science/article/abs/pii/S0960852413009498

[lxi] https://phys.org/news/2019-03-wastewater-nutrients-energy-precious-metalsscientists.html

[lxii] https://utilityweek.co.uk/precious-metals-in-sewage-sludge/

[lxiii] https://thegrowingleaf.com/organic-vs-mineral-fertilizer/

[lxiv] Institute for Industrial Productivity, Industrial Efficiency Technology Database. Ammonia. Data as of 2011.
From <https://climate.mit.edu/explainers/fertilizer-and-climate-change>

[lxv] Canfield, Donald E., et al. "The Evolution and Future of Earth's Nitrogen Cycle." Science, vol. 330, no. 6001, Oct. 2010, pp. 192–96, doi:10.1126/science.1186120.
From <https://climate.mit.edu/explainers/fertilizer-and-climate-change>
[lxvi] https://randd.defra.gov.uk/ProjectDetails?ProjectID=20110&FromSearch=Y&Publisher=1&SearchText=ME5435&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description
[lxvii] Organic fertilizer as a vehicle for the entry of microplastic into the environment, *Science Advances* 04 Apr 2018: Vol. 4, no. 4, eaap8060, DOI: 10.1126/sciadv.aap8060
From <https://phys.org/news/2018-04-microplastics-biowaste-compost-fertilizers.html>
[lxviii] https://www.unep.org/news-and-stories/story/microplastics-wastewater-towards-solutions
[lxix] https://randd.defra.gov.uk/ProjectDetails?ProjectID=20110&FromSearch=Y&Publisher=1&SearchText=ME5435&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description
[lxx] https://phys.org/news/2019-03-wastewater-nutrients-energy-precious-metalsscientists.html
[lxxi] Canfield, Donald E., et al. "The Evolution and Future of Earth's Nitrogen Cycle." Science, vol. 330, no. 6001, Oct. 2010, pp. 192–96, doi:10.1126/science.1186120
[lxxii] https://www.dwi.gov.uk/pfas-and-forever-chemicals/
[lxxiii] https://www.gov.uk/government/news/restrictions-under-new-chemical-regime-announced-for-first-time
[lxxiv] https://pubs.acs.org/doi/10.1021/acsestwater.1c00377
[lxxv] *Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)*; U.S. Environmental Protection Agency: Washington, DC, 2016.
Google Scholar
[lxxvi] Betts, K. S. PFOA and High Cholesterol: Basis for the Finding of a Probable Link. *Environ. Health Perspect.* 2014, *122* (12), 2014, DOI: 10.1289/ehp.122-A338
[lxxvii] Anna Witek-Krowiak, Katarzyna Gorazda, Daniel Szopa, Krzysztof Trzaska, Konstantinos Moustakas & Katarzyna Chojnacka (2022) Phosphorus recovery from wastewater and bio-based waste: an overview, Bioengineered, 13:5, 13474-13506, DOI: 10.1080/21655979.2022.2077894
[lxxviii] Le Fang, Qiming Wang, Jiang-shan Li, Chi Sun Poon, C. R. Cheeseman, Shane Donatello & Daniel C. W. Tsang (2021) Feasibility of wet-extraction of phosphorus from incinerated sewage sludge ash (ISSA) for phosphate fertilizer production: A critical review, Critical Reviews in Environmental Science and Technology, 51:9, 939-971, DOI: 10.1080/10643389.2020.1740545