# Sewage sludge:
## Why we need to stop pollution at source

June 2021

Pollution, both plastic and chemical, is one of the five main direct drivers of the current biodiversity crisis, impacting the functioning of marine ecosystems.[1]

Wastewater treatment is often cited as a way to prevent contaminants entering the environment. However, treated sewage sludge is routinely spread on agricultural land which, although provides nutrients and organic matter,[2] also contains the chemicals and microplastics which are captured during the treatment process.[3, 4]

Reducing contaminants entering the environment is essential to achieving good environmental status in our seas, as defined in the UK Marine Strategy.[5] This would allow for a cleaner circular economy supporting the aims of UN SDGs- in particular SDG [6] (Clean Water and Sanitation), SDG 12 (sustainable consumption and production) SDG 14 (Life below Water) and SDG 15 (Life on Land).[6]

Sewage sludge provides an excellent case study of why we must prioritise stopping pollutants at source because removing contaminants once in the environment is extremely difficult or impossible. The treatment of wastewater generates sludge, a semi-solid material. In the UK, a large majority of treated sludge (also known as biosolids) is applied to agricultural land.[7] This is an example of the circular economy where a waste product is reused, providing benefits as a soil conditioner and a source of nitrogen and phosphorus. However, sludge is known to contain contaminants such as microplastics and PFAS, [8, 9] which currently cannot be removed during the treatment process and are highly persistent in the environment. If sludge is to continue being spread on agricultural land, levels of contaminants must be controlled at source and outdated sludge regulations and monitoring must be updated to be fit for purpose.

Preventing contaminants from entering wastewater systems must be prioritised, as it is the most effective and sustainable option to reduce contaminants within sludge. However, particularly in the short-term, contaminants entering wastewater systems will be unavoidable due to historic legacy and essential uses. Therefore, regulatory limits, that reflect the modern composition of wastewater must be set for a wider range of chemicals and microplastics within treated sludge, if it is applied to agricultural land. This would ensure that contaminants from sludge are not simply transferred to farmland and then ultimately the rivers and ocean. If sludge is too contaminated to meet these new limits, innovation in treatment and alternative uses may be required and should be achieved by remaining as high in the waste hierarchy as possible. It has been demonstrated, for instance, that gasification of sludge could be an alternative route which is higher in the waste hierarchy.[10]

We ask for the following actions to be taken by Governments and regulators, businesses, individuals and water companies.

## 1. Stop microplastics and chemical contaminants from entering wastewater systems

- As a minimum, UK governments should keep up to date and fully aligned with REACH regulations, including the restriction on intentionally added microplastics and some PFAS among other concerning contaminants.[8]
- The upcoming UK Chemicals Strategy should address chemical contaminants entering wastewater systems.
- Restrict PFAS in all uses other than those considered essential for society, similar to the EU commitment in their Chemicals Strategy for Sustainability.
- The BSI PAS (Publicly Available Specification) supply chain certification for pre-production pellets should be mandatory for all companies operating in the UK.[11]
- Legislate BSI PAS Fine to Flush for any wet wipes labelled as flushable.[12]
- Extended Producer Responsibility should be applied to all products (including chemicals) which routinely end up in wastewater as is already the case in the solid waste sector.[13]
- UK governments should introduce legislation that requires washing machine manufacturers to fit microfibre filters in all new domestic and new commercial machines by 2023 and all existing commercial machines are retrofitted with microfibre filters by 2024.
- UK governments as well as textile and fashion industries, to produce a roadmap for the reduction of microfibre shedding from garments and production. This should include a publicly available standardised test and rating system, to determine microfibre loss from clothes.
- UK governments and automotive industry, to produce a roadmap for the reduction of microplastics from roads, tyre particles and paints. This should include a standardised test, and rating system, to determine material loss, as well as capture technology on vehicles and treatment of water from road runoff.

## 2. Monitoring and research programmes from source to sea for contaminants

- Monitoring programmes (such as MSFD and WFD) should be extended to include a wider range of emerging contaminants (see appendix) and microplastics, to provide an accurate picture of environmental status.
- Monitoring should cover all pathways and sinks, including terrestrial, inland water bodies, transitional, coastal and marine waters, sediments (both at the beach and offshore) and biota (including seafood), to assess contaminant levels in the whole environment and the effectiveness of source control measures.

### 3. Sewage sludge and wastewater management

- Governments should introduce thresholds for a wider range of contaminants than those currently required to be monitored in treated sewage sludge (biosolids) applied to land – including chemicals and microplastics (see appendix). Thresholds should be based on health and environmental impact, applying the precautionary principle.
- UK water companies should produce a road map on how to reduce levels of contaminants for the whole wastewater treatment process - from source control of incoming pollutants, to sludge treatment and reuse, including:
  - Monitor and determine levels of pollutants, microplastics and chemicals, that reflect modern composition of wastewater, in treated sewage sludge (biosolids), as well as influent, effluent and CSOs and make the data publicly available.
  - Applying Best Available Techniques to all treatment processes to reduce contaminant levels.
  - Where levels of contaminants cannot be adequately addressed to meet future thresholds, alternative sludge reuse and disposal options should be investigated and implemented, whilst moving down the waste hierarchy as little as possible.
- We ask farmers and retailers, and specifically their unions, to support our asks to governments, regulators and the water industry to ensure that sewage sludge, and all types of fertilisers and agricultural products, does not result in environmental contamination.

# Background

## Treatment and reuse of sewage sludge

Utilising sewage sludge as an agricultural fertiliser is encouraged in the EU as the best disposal option in reference to the waste hierarchy. Phosphorus is a finite resource and the production of nitrogen fertilisers is energy intensive, therefore, obtaining both from a waste source is considered to be a more sustainable option. The organic matter is also beneficial to the soil structure, and can help prevent land becoming yield limited.[14] Before sludge can be used on agricultural land, it has to be treated to control microbiological contaminants, such as E. coli and salmonella. In the UK, the most common treatment methods are anaerobic digestion, which also produces biogas (73% of sludge is treated in this way) and lime stabilisation.[7] In the UK, around 87% of sewage sludge is applied to agricultural land, which is around 3.5 million tonnes per year (or 170,000 truckloads).[2] The remaining sludge is used for land reclamation (6%), is incinerated (4%) or has industrial uses (3%).[7] Scotland has a lower percentage applied to agricultural land; around 54%, with 31% incinerated, 15% used for land reclamation and 0.3% sent to landfill.[15] This is similar to the EU average, where 53% is used for agriculture or as compost.[8]

Without the option of spreading sludge to land, the immediate alternatives include either incineration or landfill, which by their nature do not conform to the concept of a circular economy. In a demonstration by Yorkshire Water, gasification was shown to be an alternative route to utilise sewage sludge.[16] Yorkshire Water have established a hierarchal approach to dealing with sewage sludge, which ranks the use of pyrolysis and gasification for energy production, above anaerobic digestion for spreading on land.[10]

Although a relatively large amount of sludge is produced every year, it is only applied to a comparatively small area of agricultural land. Annually sludge is applied to about 150,000 hectares, which is approximately 1.3% of UK agricultural land.[2]

There are numerous alternatives to spreading sewage sludge on land, including chemical and mineral fertilisers which provide nutrients such as phosphate and nitrate. By using these alternative fertilisers, the circular economy approach to spreading sewage sludge is lost as it is necessary to mine for certain elements such as phosphorus. Compost and anaerobic digestate are both options for providing organic matter. These support the ideas of a circular economy because generally they are produced from green waste (e. g. household and business food and garden waste). Another option is to use animal slurry, which is again a waste product therefore adhering to a circular economy. An arrangement in Scotland called 'Muck for straw' involves arable farmers supplying straw for dairy farmers who in return supply slurry to be spread on arable land.[17]

Due to persistent chemicals such as PFAS being ubiquitous in the environment, it is likely that any other fertiliser (compost, digestate or slurry) will also contain a certain level of these chemicals. This reinforces the need to control these contaminants at source. However, contaminants such as PFAS and microplastics have a direct route into sewage sludge from consumer uses such as cosmetics and washing clothing. The recent EU Fertilising Products Regulation [18] has introduced a limit for plastics bigger than 2mm, of 2.5g/kg for composts from green waste, from 2024. In comparison sludge has been found to have a median of 4.5g/kg.[29]

## Environmental Impacts

Despite undergoing treatment, treated sludge still contains a number of different contaminants including chemicals and microplastics.[8, 9] The latter refers to plastics of typically less than 5mm, including sources from tyres, microfibres, cosmetics and industrial processes.[19] When treated sludge is spread onto agricultural land, the contaminants are re-released into the environment, and may subsequently end up in the ocean.

A clean circular economy cannot be achieved while persistent pollutants, such as PFAS and microplastics, remain in circulation. These contaminants are extremely persistent in the environment and won't break down for decades, therefore, in a circular system they will continue to build up and accumulate in the environment.

A very specific legacy problem encountered by farmers in Scotland is that of pressure from retail around previous use of sewage sludge. Some whisky producers refused crops that had been grown on land previously treated with sewage sludge.[20, 17]

The ocean often becomes the final destination of pollutants, and despite popular opinion that it is too vast to be negatively impacted, we see that marine wildlife as well as fish that we eat are impacted by these pollutants.[1, 21, 22] Microplastics can have physical impacts on the environment but may also release chemicals such as plasticizers, as well as chemicals which have become adsorbed onto the surface.[8] Persistent organic pollutants may affect successive generations of marine mammals by accumulating and passing to young through breastfeeding.[23] They impair reproduction and disrupt marine wildlife's energy balance, endocrine and immune systems, making them more vulnerable to infectious diseases [24] and other stressors such as climate change.[25]

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# Microplastics:

Although wastewater treatment works have not been specifically designed to remove microplastics, they have been found to be efficient in removing them from treated effluent, with removal rates of between 80 – 99%.[26] However, during the treatment process solid materials including microplastics, are captured within the sewage sludge [3] and if the sludge is spread onto agricultural land are subsequently released to the environment. Treated sludge is estimated to contain 69 – 80% of microplastics which enter the wastewater treatment works.[27]

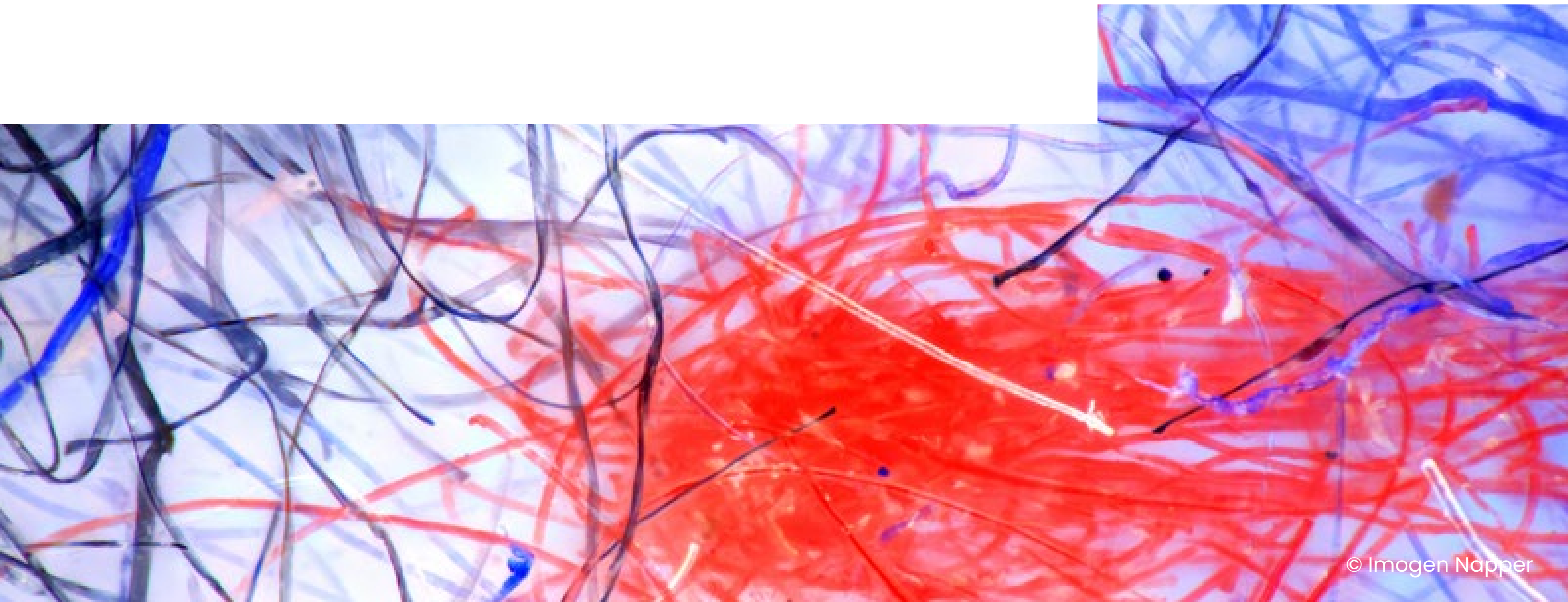
The amount of microplastics captured varies based on treatment type, with the greatest removal at preliminary (screening and grit removal) and primary stages (gravity separation and surface skimming).[26] Around 20% of microplastics are thought to be retained in the grit fraction, which in some instances is sent to landfill, but others included within the sludge.[8] It has been suggested that *"the separation of primary and secondary sludge, where applicable, could be a preventing measure to limit the release of microplastics to soil."* [3]

Many studies have reported microplastics at high concentrations in sludge.[8] Microplastics have been found in sludge at concentrations of 301 - 10,380 microplastics/g dry weight.[28] The same study estimated the annual contribution to land as roughly 2.7 x $10^{15}$ microplastics.[28] In Denmark, 4.5mg/g of microplastics (as a median) was found in dewatered sludge, equivalent to approximately 0.7% of the sludge being microplastic.[29] A study of sewage sludge from eight Norwegian wastewater treatment plants, found an average plastic abundance of 6,077 particles $kg^{-1}$ dry weight (or 1,176,889 particles $m^{-3}$) and the particles consisted of beads (37.6%), fragments (31.8%) fibres (28.9%) and glitter (1.7%).[30]

It has been estimated (within the European Economic Area) that approximately 50% of microplastics that are disposed of down the drain are subsequently released to the environment and 86% of these releases are to agricultural soil via treated sewage sludge.[8] This figure is likely to be higher in the UK where a greater percentage of sludge (around 87%) [2] is applied to agricultural land, compared to the EU average (around 53%), [8] although it may also be affected by differing levels of wastewater treatment.

Repeated sludge applications on soils leads to the accumulation of microplastics over time and results in high concentrations.[31] Nearly all of the microplastics contained in the sludge are transported to aquatic environments.[32] Microplastics have also been found to be transferred into edible fruit and vegetables [33] with proven uptake through the root systems of food crops.[34] There is also increasing concern for the impact of microplastics on human health.[35]

It should be noted that spreading treated sludge is just one of several pathways for microplastics to reach agricultural land, with other pathways including compost, anaerobic digestate, irrigation from surface waters, chemical fertilisers and degradation of plastics used in agriculture e.g. crop coverings. It has been estimated that between 5,400 – 39,700 tonnes of microplastics are released annually to soils in the European Economic Area through controlled release fertilisers, fertiliser additives, treated seeds and capsule suspension pesticides.[8] In Scotland, current modelling estimates around 160 tonnes of microplastics are added to agricultural land through the application of sludge, compared with between 334 and 2,316 tonnes from agricultural products.[15]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## Chemicals:

Sewage sludge is also known to contain chemical contaminants that end up in wastewater treatment through household and industrial use.[36] Sludge has been found to contain chemicals such as PFAS,[4] flame retardants, PCBs, and other endocrine disrupting chemicals.[37] Some of these contaminants, such as PFAS are highly persistent and therefore, similarly to microplastics, will accumulate in the environment through the repeated application of sludge to land, which ultimately compounds their effect.

In England, the Environment Agency has found under monitoring (required for the Water Framework Directive [WFD]) that no river in England has Good Environmental Status with regards to chemical contaminants.[38] Some of these failures were as a result of PFOS which is a banned PFAS chemical (banned in 2009).[39] Under the requirements for the WFD it is not necessary to monitor for the entire group of PFAS, however, it has been shown that commonly monitored PFAS including legacy PFOS or PFOA, represent only a very small proportion of the PFAS contribution in the environment.[4]

There is also emerging concern around the 'mixture effect' where organisms are exposed to a wide range of different chemicals simultaneously.[40] Currently, very little is known about the synergistic interactions between different chemicals and the effects they may have on ecosystems and species, in part due to the complexity of doing research in this area. Sewage treatment works are, in theory, an optimum place for the mixing to occur. Thus, providing a product via the sludge which contains a multitude of different pollutants and thereby resulting in subsequent exposure once spread. There is currently research ongoing, using sheep grazing on fields treated with sewage sludge, to determine the effects of being exposed to mixtures of chemicals, specifically in this case, on the reproductive system.[41]

## Antimicrobial resistance:

The long-term application of sewage sludge to fields has also been shown to increase the abundance of antibiotic resistance genes in the soil.[42] The World Health Organisation has warned that, *"Antimicrobial resistance is one of the greatest health challenges of our time"*.[43] It occurs when bacteria and viruses resist treatments from medications and make common infections harder to treat, increasing the risk of severe illness and death. Antimicrobial resistance has been accelerated by overuse of medicines in humans and livestock, as well as poor standards of sanitation and access to clean water.[43] It has been observed that wastewater treatment plants have the potential to act as reservoirs and environmental suppliers of antibiotic resistance.[44]

## Regulations

The EU Urban Waste Water Treatment Directive (UWWTD) aims to protect the environment from the adverse effects of urban waste water discharges. The Directive advocates the reuse of sludge and wastewater but provisions are limited and have never been strictly enforced due to a lack of harmonised EU standards and the potential risks to human health.[45] For example, Article 14 states that sludge *"shall be re-used whenever appropriate" and "disposal routes shall minimize the adverse effects on the environment"*.[45]

Furthermore, a recent evaluation of the Directive found that the requirements for sludge reuse were unclear, particularly in relation to *"whenever appropriate"* and the treatment required before reuse.[45] The evaluation also highlighted issues around existing and emerging pollutants, from a human health and environmental perspective.

In the UK, the regulations that cover the supply, treatment, storage and use of sludge are the Sludge Use in Agriculture Regulations 1989 (SUiAR) and the Environment Permitting Regulations (EPR). SUiAR is over 30 years old, having been introduced in 1989. In England only, these regulations will be superseded in 2023 (see later discussion). SUiAR includes provisions for the sludge and soil to be tested before application and timescales for the use of the land and crops after application. Producers need to test sludge for the following: pH, dry matter, organic matter, nitrogen, phosphorus, chromium, zinc, copper, nickel, cadmium, lead and mercury. As a later addition to the SUiAR, the Safe Sludge Matrix was first implemented in 1999 to primarily phase out the application of untreated sewage sludge to agricultural land.[46]

In 2015, the Assured Biosolids Limited not-for-profit organisation was set up (and is owned by) water companies in the UK, establishing the voluntary Biosolids Assurance Scheme (BAS).[7] One of the reasons for the water industry initiating the scheme was that *"current legislative and non-legislative controls for sewage sludge are referred to in several EU and UK documents making it difficult for third parties to establish the level of assurance they require."* [47] So, the scheme was introduced to consolidate a combination of both legislation and the water industry's current best practise to ensure safer and more sustainable use of sludge spreading on land. The BAS is not legally binding, however all water companies in the UK have signed up to be certified by the scheme. The main addition in the requirements for testing for BAS in comparison to the SUiAR is testing for microbiological parameter limits. In addition, to the regulatory and voluntary standards around sludge and its spreading on farmland, farmers are also advised by the NFU (National Farmers Union) in England specifically to perform visual inspections of the sludge that is delivered to them. This is mainly to ensure there is no large pieces of plastic or anything visibly unsuitable.

In England, additional legal requirements under the 'Farming rules for water' were introduced in 2018 to tackle diffuse water pollution from agriculture. Part of this includes reference to details on storage and application of *"organic manure"* which includes sewage sludge. Sludge must not be applied to land if there is *"significant risk of pollution"* which includes parameters such as, the condition of soil, if the land is near coastal or inland waters, the gradient of the land and any recent flooding/snowfall.[48] There are specific rules regarding treated sludge (or any other fertiliser) spreading in Nitrate Vulnerable Zones (NVZs).[49] NVZs are areas considered at risk from nitrate pollution from agricultural sources and are estimated to include about 55% of land in England. The rules are specifically regarding the methods and timings of applying nitrogen to agricultural land in these zones to ensure that water pollution is controlled.[49]

In July 2020 the Environment Agency released their 'strategy for safe and sustainable sludge use' [50] in response to concerns around SUiAR being outdated and not taking into account changes in the management and treatment of sludge, the chemical complexity of current sludge and associated potential environmental impacts. The strategy will bring sludge and septic tank sludge into the Environmental Permitting (England and Wales) Regulations (EPR) by 2023, after which SUiAR will no longer be needed but it does not address the issue of microplastics and persistent chemicals. This will only cover regulations in England and we are unaware of any other changes planned for the rest of the UK at present.

## Appendix

**Monitoring should include as a minimum:**

- Per- and Polyfluorinated substances (PFAS). Both legacy PFAS e.g. PFOA and PFOS as well as emerging PFAS, such as PFBS, PFNA, PFDA, PFUnDA and PFDoDA, used as substitutes for legacy PFAS should be monitored.[51]
- Flame retardant chemicals, including both alternative brominated [52] and organophosphorous flame retardants.[53]
- Pharmaceuticals, such as those identified in CHEM Trust's 2014 report.[54]
- Pesticides, for instance those listed in OSPAR, the WFD watch list.
- Other groups of chemicals known to contaminate the marine environment which have EDC [55] or other properties of concern, [56] including parabens, [57] bisphenols, [58] phthalates.[59]

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