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What the SLUDGE Is This?

Through the wonders of modern plumbing, it is all too easy to assume that once something is flushed down the drain, it disappears forever. Unfortunately, what we flush is coming back to haunt us in the form of sewage sludge. Repurposing sludge as fertilizer is promoted as a sustainable disposal option, but the practice is jeopardizing both our health and the environment.

Sludge is the solid remnants of the wastewater treatment process. Publicly owned treatment works (POTWs) serve approximately 76 percent of the U.S. population.[1] Everything we flush or rinse down the drain, including human waste, trash, soap, detergent, medicine, pesticides and more, flows through the sewer system, making its way to the local POTW. These facilities may also treat stormwater runoff from residential and commercial properties as well as industrial waste.[2]

POTWs in the United States need a staggering $271 billion to make vital infrastructure improvements. However, in the 1980s, budget cutters in Washington slashed federal grants for wastewater infrastructure projects, leaving many municipalities responsible for 100 percent of project costs.[3] Without sufficient funding, POTWs cannot hope to effectively remove the prescription drugs, chemicals and other pollutants that enter the POTWs every day.

Many of these contaminants enter sewage sludge, making land application of sludge a risky business. We must prioritize public health by banning the use of sewage sludge on crop and grazing land, reinvesting in our nation's wastewater infrastructure and reforming policies regulating the chemicals that end up in sewage sludge.

How Is Sludge Made?

Most POTWs employ several types of processes to treat wastewater.[6] Wastewater first passes through a screen in order to capture large objects, a process called preliminary treatment. It then enters primary treatment, which removes suspended solids through processes such as settling. Next, secondary treatment uses microorganisms to help break down and digest organic matter.[7]

Only one-third of the nation's wastewater treatment facilities provide advanced levels of treatment, also known as tertiary treatment. This includes disinfection, where chlorination or ultraviolet rays are used to kill pathogens that cause human disease. Other advanced treatment processes aim to reduce additional solids or remove nutrients like nitrogen and phosphorus.[8]

Sludge is the remaining leftovers from these processes. It contains the solids removed during treatment, along with many of the toxic pollutants and assorted chemicals that wastewater treatment is designed to remove.[9]

According to the Environmental Protection Agency (EPA), the United States generates approximately 7 million dry tons of sludge every year. That's approximately 44 pounds per person per year.[10] Nearly half of this sludge is applied to land, including cropland,[11] where any remaining pollutants can migrate into the air, soil, water and even our food system.

Biosolids vs. Sludge?

Biosolids and sludge are the same thing. The term "biosolids" is the result of a campaign to make land application of sludge more palatable to the public. Unsurprisingly, "sewage sludge" is not appealing to consumers. For this reason, the sewage industry's lobbying group, the Water Environment Federation, held a contest in the early 1990s to rename sludge. The term "biosolids" won and was promoted by the Water Environment Federation and embraced by the EPA.[4] Today, the EPA defines biosolids as sewage sludge that has been treated to meet criteria for land application.[5]

A "Chemical Grab-Bag" of Pollutants

While wastewater and sludge treatment processes do eliminate many of the harmful bacteria and viruses in sludge,[18] they are not designed to remove the myriad chemicals, drugs and other residues of modern life. Pharmaceuticals and personal care products (PPCPs) can exit the treatment plants in exactly the same form as they entered.[19] Sludge remains riddled with these PPCPs, along with toxic chemicals, heavy metals such as lead, copper, and mercury, and pathogens that were not successfully destroyed.[20]

In January 2009, the EPA released findings from the "Targeted National Sewage Sludge Survey," a project designed to characterize the pollutants in sludge. The EPA collected sludge samples from 74 nationally representative POTWs and measured the occurrence and concentrations of nearly 150 pollutants.[21] The results showed a "chemical grab-bag of heavy metals, pharmaceuticals, steroids and hormones and flame retardants," according to the *Houston Chronicle*.[22]

The survey found 9 flame retardants and 22 metals (including lead, mercury and arsenic) in 100 percent of sludge samples. Three of these metals — molybdenum, nickel and zinc — had concentrations in excess of the EPA's land application limit. Fourteen pharmaceuticals were each detected in 90 percent or more of samples. These include triclosan, an antimicrobial ingredient linked to reproductive problems and some forms of cancer that the Food and Drug Administration (FDA) has since banned from soap but still allows in toothpaste and cosmetics.[23]

However, the EPA only requires testing for and sets limits on 9 heavy metals, even though the agency has identified an additional 352 pollutants in sewage sludge. This includes 61 pollutants designated as hazardous or priority in other agency programs. A 2018 report by the EPA's internal watchdog slammed the agency for its failure to determine whether these other pollutants pose a safety risk in sewage sludge application.[24]

Sludge Classifications

The EPA sets criteria for sewage sludge destined for land application. Sludge must undergo "vector attraction reduction" (VAR) to deter flies, rodents, and other disease-carrying pests, and may not exceed concentration limits for nine heavy metals. Additionally, to be considered Class A, sludge must be treated to reduce pathogens to below the levels of detection.[12]

Class B sludge is also treated, but some pathogens may remain. It can be applied anywhere except lawns and home gardens. Use of Class B sludge requires additional safeguards to prevent the spread of disease, such as restricting public access or livestock grazing following sludge application.[13]

Additionally, "Exceptional Quality (EQ)" sludge meets Class A pathogen reduction requirements, has low levels of pollutants and has undergone even stricter VAR treatment.[14] It can be used anywhere without restriction, including on lawns and home gardens.[15] The EPA does allow public sale of sludge that exceeds EQ pollutant concentrations, requiring users to comply with application limits. However, as the National Academies of Sciences pointed out, the EPA has no way of guaranteeing that the public will know of or follow these application limits.[16]

In the end, no sludge treatment can completely remove toxic pollutants like heavy metals, pharmaceuticals and flame retardants.[17]

Clearly, the EPA's sewage sludge program does not come close to addressing the 85,000 or more chemicals that have been used in the United States that could potentially end up in wastewater systems and sludge.[25]

Per- and polyfluoroalkyl substances (PFASs)

PFASs (including PFOA and PFOS) are a family of chemicals valued for their heat and water resistance and are used in a wide variety of consumer products, from stain-resistant fabrics to food packaging to non-stick cookware.[26] However, their stability means that these chemicals do not break down easily, and advanced wastewater treatment processes do not necessarily remove them. In fact, some treatment processes may increase the concentrations of certain PFASs.[27] PFASs accumulate in the environment, so much so that even after PFOA and PFOS were phased out of U.S. production, the concentrations of these toxic chemicals found in sewage sludge remains the same.[28]

PFASs also accumulate in our bodies and are linked to a host of health effects including decreased fertility, asthma and some forms of cancer.[29]

Sewage sludge contributes to the widespread PFAS contamination of our drinking water and food. Contaminated sludge leaches PFASs into the soil and groundwater.[30] Plants grown on sludge-applied fields or with contaminated irrigation water can absorb and accumulate PFASs in their edible tissues.[31] Dairy cows fed contaminated forage or feed may excrete up to 100 percent of PFOS through their milk.[32]

Frustratingly, the EPA has yet to establish enforceable limits on PFASs in drinking or irrigation water, and no federal agency regularly monitors our food for PFAS contamination.[33] And our government's piecemeal approach to chemical regulation means that manufacturers are free to replace PFOS and PFOA with some of the thousands of other chemicals in the PFAS family.[34]

Endocrine-Disrupting Chemicals

Wastewater and sludge are major sources of endocrine-disrupting chemicals in the environment.[35] These chemicals mimic the body's natural hormones and interfere with normal growth and functioning. Exposure to endocrine disruptors can harm reproductive and cognitive health and may lead to ovarian, breast and prostate cancers.[36] Endocrine disruptors in wastewater effluents are also linked to a variety of reproductive changes in aquatic wildlife, including the occurrence of intersex fish.[37]

Bisphenol A (BPA) is one of the more familiar endocrine disruptors, due to controversy over its use in

baby bottles and sippy cups. In 2012, the FDA banned the use of BPA in these products, but it still allows it to be used in numerous consumer goods including plastic drink packaging and food can linings.[38] BPA from consumer products and industrial sources is not completely removed by POTWs and, according to a global survey, is a "ubiquitous environmental contaminant" in sewage sludge.[39] And while manufacturers are promoting "BPA-free" products to consumers, some replacement chemicals come from the same family, with similar health concerns and persistence in sewage sludge.[40]

Antibiotics

Antibiotic-resistant superbugs are one of the world's most pressing public health crises, and POTWs play a significant role in spreading antibiotic-resistant genes from human sources into the environment. Antibiotics enter the wastewater stream through human urine and feces, pharmaceutical factory waste and improper disposal (such as flushing unused antibiotics down the toilet).[41] They are not completely removed by POTWs and can end up in sewage sludge, which is also high in bacterial diversity, creating fertile ground for the development of antibiotic-resistant bacteria. These resistant bacteria can spread to humans and livestock when sewage sludge is applied to land.[42]

Heavy Metals

In many municipalities, household waste streams combine with industrial waste streams, placing an even greater burden on POTWs.[43] In 2017, industrial sites in America reported transferring 1.2 million pounds of metal and metal compounds to POTWs for treatment, including 112,000 pounds of lead and lead compounds.[44] Lead is toxic and especially harmful to children, as it can impair physical and mental development.[45]

Disturbingly, EPA regulations allow high concentrations of heavy metals in sludge — levels that far exceed those allowed in Europe and that may not be protective of human health.[46] Additionally, sludge that does not meet these requirements for application on farmland but that still falls below the total limit for heavy metals can be sold to home gardeners, putting vulnerable populations like children at risk.[47] Sewage sludge application can also lead to heavy metal accumulation in soils, which impacts plant health, reduces soil quality and introduces these toxic substances into the human food system.[48]

Microplastics

"Plastic pollution" might bring up images of trash floating in our oceans and rivers, but microplastics (pieces smaller than 5 millimeters) also pose

significant risks to the environment on land. Emerging research suggests that agricultural and urban soils might in fact be some of the largest environmental sinks for microplastics, possibly exceeding even the ocean. Sewage sludge application is likely a major source of this microplastic pollution.[49]

Microplastics are used in industrial and consumer goods (such as microbeads in cosmetics) and are also released during the breakdown of products like synthetic textiles and plastic waste.[50] POTWs capture the majority of microplastics during the settling stages of treatment, but even so, POTWs release an estimated 13 billion microbeads each day into U.S. waterways.[51] Additionally, the microplastics "captured" in wastewater treatment end up in sludge, where treatments are far less effective at removing the smaller particles. Some processes reduce microplastics into even smaller pieces.[52]

Microplastics in sewage sludge damage the soil ecosystem and introduce toxic chemicals associated with plastic manufacturing, putting our food system at risk. They can also migrate into aquatic environments like groundwater aquifers.[53] Disappointingly, the EPA's regulations for sewage sludge do not address microplastics. And due to their small size, it is difficult to even quantify the levels of microplastics in sludge and soil.[54]

The Many Risks of Sewage Sludge

Tainted Food Chain

Sewage sludge introduces chemicals and pathogens into our food chain. According to the EPA, soil amended by sewage sludge can remain on crops even after washing,[61] potentially exposing consumers to contaminants in sludge. Repeated application of sewage sludge can increase soil concentrations of pollutants, which can be taken up by plants and accumulate in edible tissues.[62] Sludge contaminants can also migrate into groundwater that is used for irrigation and cattle watering.[63]

These impacts may not only contaminate our food supply but also threaten farmers' livelihoods. One Maine dairy farmer applied sludge on his hayfields for

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Greenwashing Toxic Fertilizers

Private companies are capitalizing on the sludge-to-fertilizer business, which has grown into a multi-million-dollar industry. POTWs pay companies like Synagro to collect sludge and apply it to farmland. The POTWs save money that would otherwise be spent sending sludge to a landfill or incinerating it, and farmers may pay next to nothing for the fertilizer.[55] Synagro also processes sludge into pellets that it then sells to fertilizer manufacturers that blend it with other inputs.[56]

Some POTWs sell or give away their sludge to residents as packaged fertilizer.[57] For example, Washington, D.C.'s water authority recycles its sludge and sells it under the name Bloom, assuring the public it is "safe" and meets EPA standards. DC Water downplays concerns about toxic contaminants, claiming that these are "found nearly everywhere in modern society," with higher levels of flame retardants in household dust than in sludge.[58]

However, the EPA Inspector General's 2018 report slammed the EPA for its lack of assessment of 352 pollutants found in sewage sludge, concluding that the EPA "cannot say, whether the pollutants are safe or unsafe when found in biosolids."[59] The report also found that current labeling standards for such fertilizer fail to address these risks and "as a result, consumers are unable to make an informed decision about the use or purchase of biosolids." Notably, the report highlights flame retardants as an unregulated pollutant in sludge tied to health impacts such as reduced IQ and thyroid disruption.[60]

decades at the state's encouragement. Fifteen years after he stopped applying sludge, water wells on his land still have alarming levels of PFASs, forcing him to dump his milk and threatening the economic survival of his century-old farm.[64]

The U.S. Department of Agriculture's (USDA) organic standards prohibit the use of sludge in any segment of organic crop production.[65] But unfortunately, home gardeners can easily be misled by the PR term "biosolids," especially when the material is described as "organic" by municipalities eager to get sludge off their hands.[66]

Public Health

Humans can be exposed to bacteria and other contaminants in sludge applied to land through inhalation of dust following application and from contact with contaminated soil, water and food.[67] Common health symptoms of residents living near sludge "dumping ground[s]" include headaches, gastrointestinal issues, nosebleeds, fatigue and respiratory problems. This so-called sludge syndrome is likely from exposure to pathogens and irritating chemicals emitted from sludge.[68] The odors also prevent residents from spending time outdoors and engaging in social activities. Some express frustration at inadequate notification about sludge application and that their complaints to public officials fall on deaf ears.[69]

In 2002, the National Academies of Sciences urged the EPA to establish a formal procedure for tracking and investigating health complaints.[70]

The EPA pawned this responsibility onto the Water Environment Research Foundation (WERF), the research arm of the industry lobbying group behind the clever marketing strategy that renamed sludge to its more consumer-friendly name "biosolids." WERF developed a generic protocol for tracking health complaints to be used by state and local health officials, but there is no federal mandate to implement this protocol.[71] Meanwhile, the EPA continues to make its biosolids program a "lower priority," cutting funding and staff, which ultimately weakens the EPA's ability to oversee sludge application.[72]

Antibiotic Resistance

Sewage sludge application adds to the growing burden of antibiotic-resistant genes in the environment. Antibiotic residues removed from wastewater can concentrate in sludge, which is also high in bacterial diversity, creating a favorable environment for the development of antibiotic-resistant genes and the bacteria that carry them.[73] Additionally, the presence of heavy metals in wastewater during treatment processes may increase the incidences of resistance to certain types of antibiotics.[74]

Soil Degradation

Pollutants in sewage sludge impact soil health. Heavy metals are one of the most significant soil pollutants, and long-term application of sludge can increase their accumulation in soil. Heavy metals disrupt the soil ecosystem, reducing microbial diversity and impacting soil function.[75] Antibiotics have a similar effect, killing

What Would the EU Do?

The European Union (EU) produced nearly 4 million metric tons of sewage sludge in 2015. Some countries sent all of their sludge to landfills, while others applied a portion to agricultural land, with Ireland applying the most (80 percent).[78]

While EU regulations only limit concentrations of certain heavy metals in land-applied sewage sludge, many member states have taken it upon themselves to set stricter standards for these and other pollutants.[79] For example, Germany, Bulgaria and France have set limits on chemical contaminants like polychlorinated biphenyls (PCBs).[80] The chief difference between the EU and the U.S. approaches is that the EU adheres to the "do no harm" precautionary principle, seeking to limit pollutant inputs to soil so that they do not rise above background levels. By contrast, the U.S. EPA uses risk assessments to set application limits for heavy metals to levels that do not cause "unacceptable harm." This approach increases heavy metal levels in soil after long-term application.[81]

or impacting the activity of microorganisms vital to soil processes.[76] Other pollutants like nanoparticles affect other important soil species such as earthworms, which may experience reduced reproduction.[77]

No Appetizing Alternatives

Prior to the enactment of the Ocean Dumping Ban Act of 1988, sewage sludge could be collected and dumped into the ocean.[82] But with an expanding "garbage patch" in the Pacific Ocean, offshore oil spills and climate change, resuming ocean dumping is not a solution to our sludge problem.

POTWs have few remaining options to dispose of sewage sludge, and the organic matter in sludge makes land application and use as fertilizer attractive solutions. In 2016, major U.S. POTWs applied roughly half (47 percent) of all sludge generated to land. They sent the remaining sludge to landfills and other surface disposal sites (6 percent), incinerated it (15 percent) or put it to other uses (32 percent), including deep well injection and gas production.[83]

Incineration of sewage sludge is a practice that should be discontinued. It releases pollutants like heavy metals and particulate matter and is linked to worsening asthma symptoms and heart attacks.[84] Additionally, the incineration of sludge contaminated with triclosan could be a major contributor to dioxin emissions in the United States. Dioxins are a family of compounds, the most toxic of which — 2,3,7,8-TCDD — was found in Agent Orange and may cause reproductive damage and some types of cancer in humans exposed to it.[85] Triclosan can concentrate in sewage sludge and be converted into dioxin-like compounds during incineration. Modeling results suggest that triclosan accounts for between 3.6 percent and 100 percent of dioxins released from sewage sludge incineration.[86]

Any discussion about what to do with sewage sludge must include revamping our policies regulating which chemicals end up in the wastewater system.

Fortunately, there are signs that incineration is losing popularity with the EPA. In the spring 2011, the EPA finalized new emission standards and guidelines under the Clean Air Act for sewage sludge incinerators at wastewater treatment facilities. The final rule limits emissions of nine pollutants, including cadmium, carbon monoxide, lead, dioxins and mercury. The EPA estimates that the new guidelines will reduce emissions of non-mercury metals such as lead — which is harmful to children's developing brains — by 1.7 tons per year.[87]

The ugly truth is that none of the above treatment or disposal options prevent the spread of contaminants into the environment, which is why any discussion about what to do with sewage sludge must include revamping our policies regulating which chemicals end up in the wastewater system.

Recommendations

Current U.S. sludge policies are based on antiquated science and are grossly out of date. Back in 2002, the National Academy of Sciences advised the EPA that "additional scientific work is needed to reduce the persistent uncertainty about the potential for adverse human health effects from exposure to biosolids."[88] In 2018, the EPA's internal watchdog criticized the "weaknesses" in the agency's sewage sludge program, including its failure to regulate any new pollutants in the program's 25 year history.[89] Even WEF, the EPA's partner in promoting sludge, said that the agency has shown "minimal support" for the national biosolids program because it believes "the risk of biosolids recycling is small."[90]

To begin tackling this problem, POTWs need federal funding to repair aging infrastructure and to install improved treatment technologies. The EPA estimates that POTWs need $271 billion nationwide to make

basic improvements to keep up with Clean Water Act objectives.[91]

Yet the simplest solution of all is pollution prevention. Our federal agencies must keep untested, potentially harmful chemicals from going to market — and down the drain — in the first place. The fact that thousands of chemicals permitted for use in consumer goods and personal care products remain untested for safety, efficacy and environmental impact, including through wastewater treatment and sludge disposal, is negligence on the part of our federal government.[92] A precautionary approach to chemicals management would greatly reduce the toxicity of sludge, yield cleaner water and ease the economic strain on POTWs.

Demanding better chemicals policy and standards for sludge is critical. Otherwise, it is the POTWs and utility operators who will bear the brunt of this burden. The responsibilities to craft adequate regulations fall squarely on the shoulders of federal agencies like the EPA.

Short-term Recommendations:

- Prohibit the sale or distribution of sludge to farmers and home gardeners.
- Prohibit application of sludge on land.

Long-term Recommendations:

- Prohibit the use of toxic chemicals in household, pharmaceutical and personal care products, as well as additives like microbeads that contribute to plastic waste.
- Mandate that industries treat their waste to the same pathogen and contaminant standards as municipal sewage.
- Mandate that industries safely dispose of treated waste in a way that is protective of human and environmental health.
- Employ a precautionary approach to chemical and technological regulation to limit the number of endocrine-disrupting and other toxic chemicals that end up in the wastewater system.

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