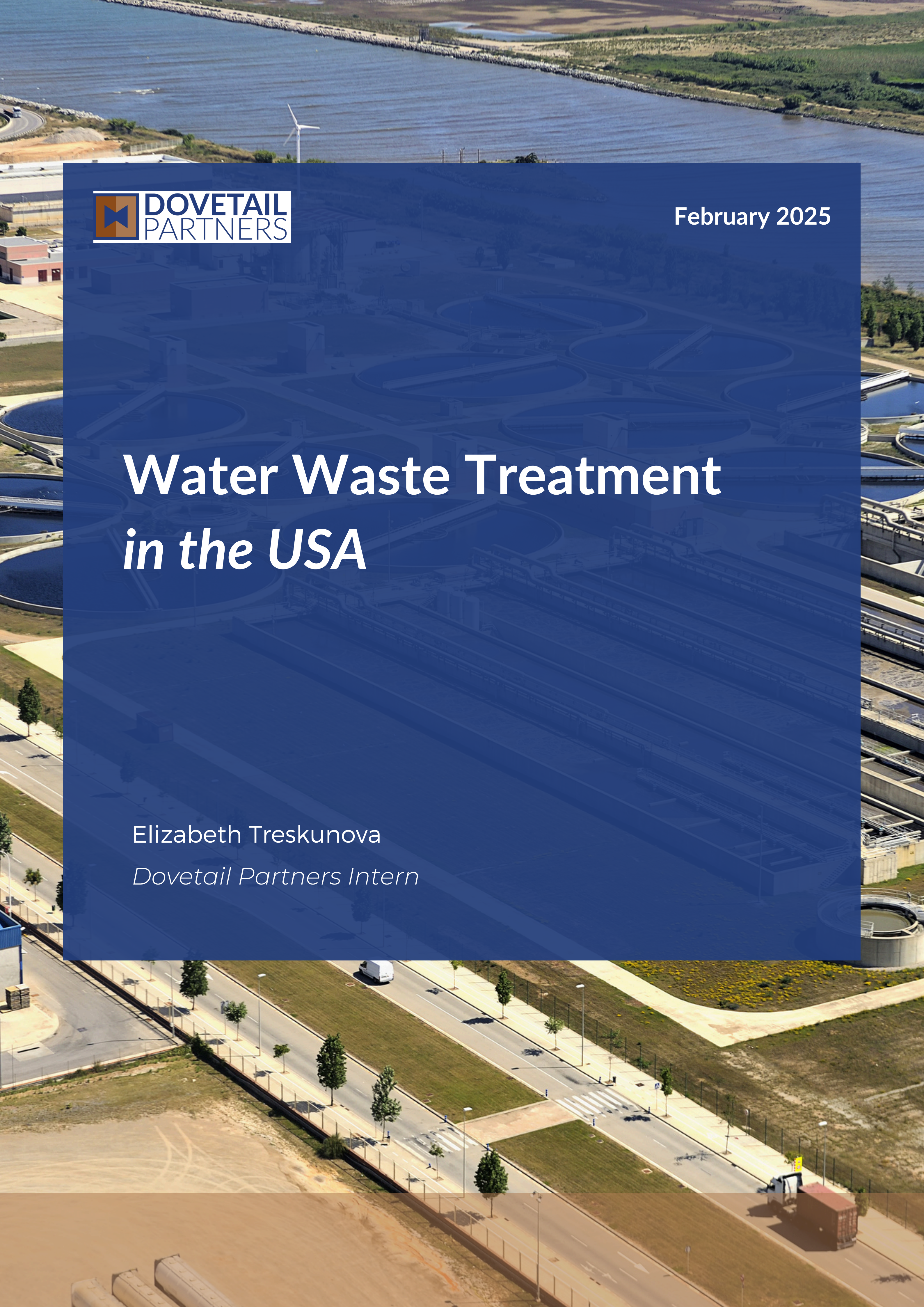

DOVETAIL PARTNERS

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Water Waste Treatment *in the USA*

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INTRODUCTION

The idea of changing the taste of drinking water has been around as early as 4000 BC, with examples including Sanskrit and Greek writings prescribing methods such as boiling, sun exposure, straining, and charcoal filtering. Currently, there are different types and steps to the wastewater treatment processes in the USA and around the world, with most of them depending on the source and intended use of the water, whether that be commercial or industrial. One of the biggest national issues facing wastewater treatment today is its average age of 33 years and grade of “D” from the American Society of Civil Engineers (ASCE). The inefficiency of the US Water Waste Treatment System (WWTS) stems potentially from a lack of public involvement and funding, which could be remedied with an increase in education and awareness paving the way for funding and consequently cleaner water.

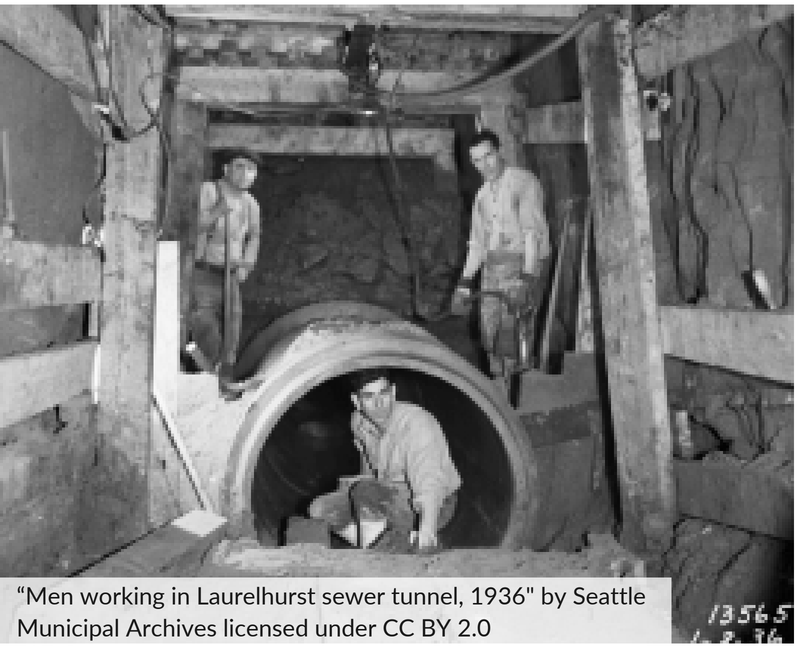
A Waste Water Treatment in Antwerp, Belgium.
Annabel, CC BY-SA 3.0, via Wikimedia Commons

HISTORICAL BACKGROUND

In 1500 BC, the Egyptians discovered coagulation when chemical alum was mixed with their waste water. During 500 BC, Hippocrates invented a type of filter to trap sediments in wastewater. From 300-200 BC, aqueducts were built by the Assyrians and were, “...the first structure that could carry water from one place to another...”. They worked primarily by using gravity and carried water over extremely long distances. Through the middle ages (500-1500 AD) also known as the Dark Ages there was little scientific innovation, and it wasn’t until 1627 that Sir Francis Bacon tried to experiment with desalinating seawater. He was unsuccessful, but this paved the way for other scientists to experiment with a focus in understanding water treatment. The 1700s saw the first water filters for domestic application, and in 1887 the first treatment (an intermittent sand filter) was introduced in Medford, Massachusetts. In 1912 the concept of biochemical oxygen demand was introduced and an increase in advancements was seen after WWII. In 1972 the Clean Water Act was passed, which “...establishes the basic structure for regulating discharges of pollutants into the water of the United States and regulating quality standards for surface waters.”

Science of Waste Water Treatment

Wastewater is "...a complex mixture of chemicals and biological markers..."[8]found in used freshwater. Treated wastewater is wastewater that has been cleaned or processed to a certain standard which qualifies it to be discharged back into the environment.[9] Commercial uses of treated wastewater[10]include cooling, boiler feed, irrigation, and process water. There are also many steps of wastewater treatment, which include but are not limited to coagulation, flocculation, sedimentation, filtration, disinfection, and a number of biological processes.[11] For treating wastewater, coagulation is generally the first step in the process, and involves adding chemicals to the water that help particles bind together by destabilizing their charges. Chemicals commonly used are iron, various salts, and aluminum sulfate (which can act as both a coagulant and flocculant). Flocculation is the next step, where the water mixture is gently mixed to help the particles aggregate together to form heavier particles called flocs. These flocs become so heavy that they float to the bottom, also known as sedimentation. Filtration is next, where the flocs are removed from the mixture or recycled back into the wastewater not yet treated. The cleaner water on the top goes through several filters. Disinfection is often the last step, where the filtered water has either chemical disinfectants (chlorine, chloramine, or chlorine dioxide) added to it or is run through a UV light filter. This kills any remaining pathogens and/or harmful bacteria.

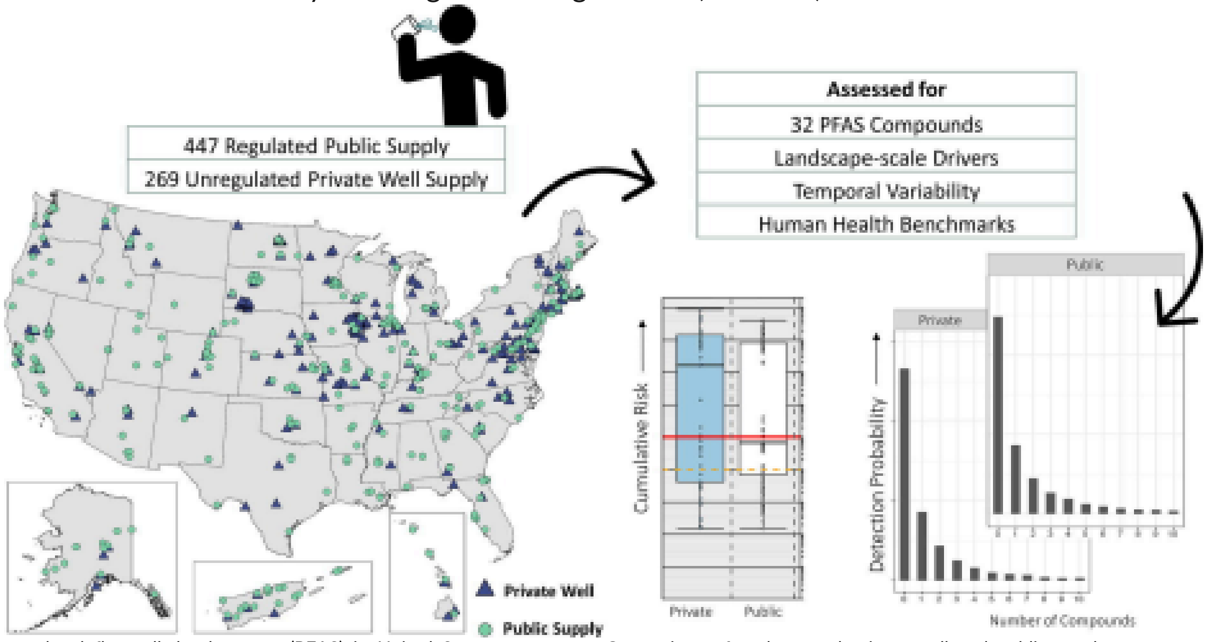

"Men working in Laurelhurst sewer tunnel, 1936" by Seattle Municipal Archives licensed under CC BY 2.0

Aging Infrastructure

The infrastructure of many wastewater treatment plants (WWTPs) are a couple of decades old and their inefficient and outdated systems frequently break down, which can lead to the potential for untreated discharges. "There are 600,000 miles of sewer pipes across the country...some pipes in cities along the eastern seaboard are nearly 200 years old. Some are even made of wood." There is also an issue that older cities have combined sewer systems that carry both storm and sewage water, which during heavy rains can overflow and contaminate waterways with untreated sewage. There is limited funding for maintenance and upgrades and many smaller cities and towns do not have access to grants and loans for improvements to their own facilities. Their systems are also less regulated since they rely mostly on small scale treatment where there is a lack of technical expertise.

Water Contaminants, PFAS, and Fertilizers

Contaminated bodies of water can poison aquatic organisms and eventually the humans who eat them. The National Primary Drinking Water Regulations (NPDWR) Contaminant list



“Per- and polyfluoroalkyl substances (PFAS) in United States tapwater – Comparison of underserved private-well and public-supply exposures and associated health implications” by Authors of the study: Kelly L. Smalling, Paul M. Bradley, Matthew C. Morriss, James L. Gray, Leslie K. Kanagy, Stephanie E. Gordon, Brianna M. Williams, Sara E. Breitmeyer, Daniel K. Jones, Laura A. DeCicco, Colin A. Eagles-Smith, and Tyler Wagner is licensed under CC BY 4.0.

has 6 major contaminant categories that require different levels of specific microorganisms and chemicals for water that meets required standards for reuse, which include Microorganisms, Disinfectants and Byproducts, Inorganic and Organic Chemicals, and Radionuclides. Polyfluoroalkyl substances, also known as PFAS, are ‘forever chemicals’ that can leach into water through plastics and are challenging to remove with current treatment methods. They were first discovered in the 1930s, and eventually came to be used in many different products starting in the 1950s including Teflon, water resistant clothing, and food packaging materials. It was discovered in the 1990s that traces of PFAS were found in the environment, does not degrade, and can eventually accumulate in animals. PFAS has been linked to numerous adverse health problems like decreased fertility, developmental delays in children, increased risk of cancer, reduction in fighting ability of immune system, and increased levels of cholesterol and obesity. Pharmaceuticals and Personal Care Products (PPCPs) are also often disposed of into the water system and often don’t get filtered out through conventional treatment, while microplastics linger in water that has been treated and end up back in the ecosystem. Untreated wastewater with antibiotics can help antibiotic resistant bacteria proliferate, eventually reducing the strength of antibiotics. PFAS is still affecting the US and starting in January of 2020, “...water systems that receive a monitoring order and detect levels of PFAS substances that exceed the RL shall take a water source out of use, treat the water delivered, or provide public notification”. Another source of water pollution is commercial and home use of fertilizers. On many farmlands fertilizer is used to increase the yield of crops, but the excess can end up in rainwater runoff and contribute excess amounts of nitrogen and phosphorus to it. According to the US EPA, “...the proliferation of newly introduced nutrients stimulates plant and algae growth, which in turn reduces oxygen levels in the water. This dearth of oxygen, known as eutrophication, suffocates plants and animals and can create “dead zones,” where waters are essentially devoid of life.” Recreational swimmers and fishers can get digestion issues, skin infections, and general health problems from ingestion of water and aquatic organisms that live in polluted waters. This can also harm tourism, fisheries, and eventually communities that live close or nearby them.

Wastewater Treatment Regulations

The Environmental Protection Agency (EPA) Office of Water is primarily responsible for the regulations and policies surrounding WWTPs in the USA, and "...ensures drinking water is safe, and restores and maintains oceans, watersheds, and their aquatic ecosystems to protect human health, support economic and recreational activities, and provide healthy habitat for fish, plants and wildlife". It also sets the standards for drinking water quality and monitors states, local authorities, and water suppliers who enforce those standards. Bruno Pigott is the current head of the US EPA's Office of Water and is in charge of managing the National Water Program. Currently the US government enforces the Clean Water and Safe Drinking Water Act through the EPA by monitoring water quality by conducting inspections, reviewing compliance records, issuing administrative order and taking legal action against those that do not meet safety standards. Each state is responsible for its own local wastewater compliance and enforcement, and information about the system in Minnesota can be found at the website of the Minnesota Pollution Control Agency (MPCA). Current levels of pollution in urban areas, suburban, and wildlife areas are influenced by different factors such as industry, agriculture, and urban development. In urban areas, stormwater runoff is the biggest contributor because surfaces such as roads and buildings prevent the water from naturally filtering through the ground. This water carries with it all contaminants that might have been on these surfaces, such as oil, grease, and heavy metals. The largest contributor to suburban pollution comes from lawn fertilizers, pesticides, and septic system leakage.

Point Source vs. Nonpoint Source Pollution

Point source pollution is defined by the EPA as "...any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack."[10] In wildlife areas, the main source comes from agricultural runoff of fertilizer and pesticides.

Non-Point Source Pollution "...generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. NPS pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse Sources." [32]

Waste Water Treatment in Other Countries

Other countries have similar waste treatment processes as the US. The United Kingdom, Finland, and Sweden scored 100 in the Environmental Performance Index (EPI) report, which ranked, "...180 countries on 24 performance indicators of environmental health, including drinking water safety, sanitation and wastewater treatment". The USA scored 89.2 for drinking water, 81.4 for sanitation, and 58.9 for wastewater treatment. In Sweden, only 1% of waste ends up in landfills, while the other 99% is either recycled or burned for energy. This lightens the burden on plants by effectively preventing waterway contamination in the first place. They also have stricter standards for quality, which govern the entire nation's water treatment system. In comparison, 50% of the waste generated in the USA ends up in landfills, while only 12% of waste ends up being used for energy, Three major industries that can't be sustained without wastewater treatment include Agriculture/Food Production, Dyeing Textiles, and Manufacturing Chemicals, all of which produce a substantial amount of toxic chemicals that left untreated could significantly damage the ecosystem and human health.

Solutions and Innovations

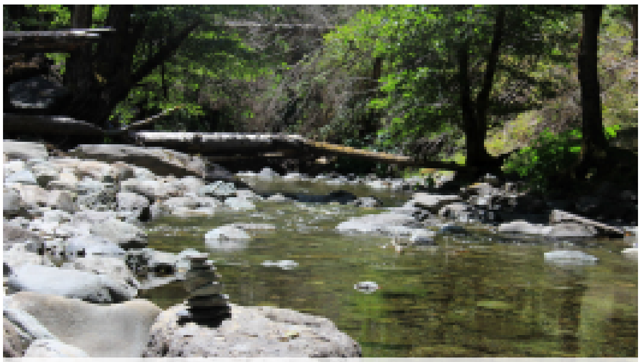
In order to increase the efficiency and fix the problems of the current issues in the USA, ideas like recovering resources, circular economy integration, and decentralized/modular treatment systems are at the forefront. Resources can be recovered by means of processes creating byproducts that can be reused. Electricity can be generated from the leftover carbon dioxide and methane produced during anaerobic digestion by microbes during the aeration process of activated sludge, which can power the facility by using it in fuel digesters. Current processes are well designed to filter out large particles, kill bacteria, and use coagulants and flocculants to further filter water, but struggle when it comes to filtering new contaminants such as medicines, PFAS, and parasites. Fixing these problems would require substantial investments and funds to upgrade current processes to meet standards. Opportunity costs of not adopting any type of resource recovery during the treatment process, and not integrating advanced technologies are often in the form of lost profit, which can also often be expensive or not readily available. Most wastewater treatment is paid through user fees from households, businesses, local government funding, and is energy intensive, with about 2% of all the energy in the US going towards treating it. 50-60% of the treatment facilities energy is used by the pumps during the aeration process, and there is a potential for improvement in this area if the pumps could be made more efficient, effectively lowering the energy costs of treating water across the entire US by a substantial amount. Many innovative new technologies are emerging that could be applied to the US.

Water reuse and recycling is cost effective and only requires that water be reused in one location involving onsite systems, thereby reducing utility costs and consumption of fresh water. PFAS destruction technologies are still developmental, but some companies have created a highly efficient Electrochemical Oxidation (EOx) process that, “involves the passage of an electrical current through a liquid solution to mineralize PFAS compounds on the anode surface” which requires less energy.

Rain gardens in New York City are improving streets by reducing ponding, providing shade, and greening communities. They allow rain to seep through the ground instead of into the sewer system, lightening its load. In Virginia, the Noman Cole Treatment Plant Rehabilitation and Replacement Project is underway with continuous operations that results in effluent quality that, “...consistently meets, or surpasses, strict national and state water quality requirements.” Commercially effective emerging technologies come with their advantages and disadvantages. Microbial Fuel Cells can produce energy and treat wastewater at the same time by helping bacteria produce charged electrons. They are exceptionally efficient but cannot compete with substitute technologies due to their high cost. Nanofiltration is an advancing technology that uses pressure and membrane technology to treat water and lies between the processes of ultrafiltration and reverse osmosis.

Role of Forests

Forest watersheds are primarily a forested area that "channels rainfall, snowmelt, and runoff into a common body of water." The largest amount of water filtering into water treatment facilities



"Mule Creek" by BLM Oregon & Washington is licensed under CC BY 2.0

comes from forest watersheds, so most of the treatment is done for these types of topland wastewater. If forest watersheds are converted to other land uses or developed, WWT facilities would need to upgrade equipment and processes to address additional contamination or switch from utilizing surface water to groundwater. This technology can be costly and numerous pumps would be required to push water up from below. As stated before, currently the majority of energy from the most important WWT process is used by aeration pumps. Based on the percent of energy used for these processes, water treatment for groundwater would be significantly more energy intensive than what it currently is. Currently, surface waters account for 74% of water use in the US.

Improving Wastewater Treatment Starts at Home

Improvements in the USA's WWTS can be made by increasing awareness of water treatment and upgrading technologies that help the process of it. To lighten the burden on process treatment plants, a greywater collection system can be set up at home. This system collects rainwater which can be used for gardens, the laundry, or bathroom. Websites to help with these projects include www.waterwisegroup.com and www.greywateraction.org. Turning off the faucet when you brush your teeth or only running the washing machine or dishwasher with a full load are some more ways to help. The top 5 things you can do to conserve water are

1. Take shorter showers
2. Fix leaks
3. Turn off water after brushing your teeth
4. Use your automatic washing machine and dishwasher efficiently
5. Collect rainwater

"Rainwater-collection-drum" by Kmtextor is licensed under CC BY-SA 4.0.

Conclusion

The effectiveness of the USA's waste water treatment system is tied to its age, funding, and public awareness. PFAS and other forms of pollution are the biggest contributors to the strain on WWT Plants, and the USA is lagging behind in infrastructure and systems that would fix these issues. Improvements in infrastructure are not properly funded and new technology is inaccessible and costly. With more involvement and awareness from the public, the USA's WWTS could be upgraded and eventually lead to a more sustainable waste water treatment system.

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