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Microplastics Pollution inWastewater Treatment Plants: A Comparative Study

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ABSTRACT:

Microplastic pollution is an escalating environmental concern globally, and India is no exception. This review synthesizes current research on microplastic contamination in sewage treatment plants (STPs) in India. It explores the prevalence, sources, pathways, and removal efficiencies of microplastics in these facilities. The implications for environmental health, regulatory challenges, and recommendations for improved management practices are discussed.

KEY WORDS: Microplastic pollution (MPs), Sewage Treatment Plants (STPs) Wastewater Treatment (WWT), Pollution, Health and Environment.

1. Introduction:

Plastic utilization has become vivid in industries comprising cosmetics (Juliano and Magrini 2017; Jacob et al. 2020), textiles, furniture (Abbasi et al. 2019), food packaging, disposable kitchen products, and in the pharmaceutical industry (Patel et al. 2009). Consequently, their production has been steadily augmenting over the past 30 years, ensuing in plastics permeating every aspect of our daily lives. Synthetic polymers owing to characteristics lightness, variability, strength as well as persistence resulted in replacement of conventional materials in diverse operations in day-to-day purposes (Cverenkárová et al. 2021). Plastic pollution has arisen from the accumulation of plastic waste in landfills and oceans due to insufficient recycling practices, despite the rising production and low biodegradability of plastics in the environment.

Micro-plastic (MP) contamination has become pervasive in global waters resulting a probable health concern to biotic environment (Ou and Zeng 2018). Plastic particles having size < 5 mm (1μm – 5 mm) are often regarded to be microplastics (Carr, Liu, and Tesoro 2016)(Frias and Nash 2019). Wastewater treatment plants (WWTP) considered to be the connected betwixt the natural and anthropogenic water cycles, are often regarded to be the receptors of MPs from domestic as well as industrial effluents. Recent studies depicted traces of MPs in multiple packaged food products likely salt, tea-bags, cups, fish and milk (Joseph et al. 2023). The dispersion of harmful by-products from microplastics, such as Di 2-ethyl hexyl phthalate (DHEP), Dibutyl phthalate (DBP), and Phthalate Acid Esters (PAE), has been extensively studied. MPs often interact with heavy metals, organic pollutants, and additives (Hajiouni et al. 2022; Mohammadi et al. 2022; Takdastan et al. 2021).

Prevalence of Microplastics in Indian STPs

Studies have consistently demonstrated significant microplastic contamination in various stages of sewage treatment. Vaid et al., 2021 (Vaid, Mehra, and Gupta 2021) reported substantial concentrations of microplastics in the influent, effluent, and sludge of STPs across India. Patel et al. (2020) highlighted similar findings, emphasizing the inefficiency of current treatment processes in removing microplastics from sewage.

Microplastics in wastewater and sludge

Emergence of microplastics in urban wastewaters has varied sources owing to over-utilization of plastics in anthropogenic activities (Sol et al. 2020). MP contamination in urban wastewaters has become prevalent owing to large intrusion of personalized products, cosmetics, bitumen, detergents and vehicular fluids in influent. Consequently, MPs infuse into treatment plants since WWTPs are sinks connecting wastewater sources and water bodies. Hamidian et al., revealed STPs do served as MP sinks due to their entrapment in sludge post-wastewater treatment (Hamidian et al. 2021). The sludge generated from such STPs would inherit MPs which could enter soil strata resulting disruptions in terrestrial eco-system.

Usually sludge generated in wastewater treatment plants induced with nutrients are utilized for agricultural soils as supplement for nourishment (Henry, Laitala, and Klepp 2019). Contaminated MPs in influent wastewater may aggregate in sludge during primary and secondary treatment, and they may be readily recovered by gravity settling into sewage sludge, according to (Hamidian et al., 2021; Park et al., 2020).In addition, the findings verified the research of Collivignarelli et al. (2021), that found that the treatment design of the process and MP abundance in influent wastewater had an impact on the concentration of

MP in sewage sludge. MPs can simply attach to sludge or microbes in the tank used for aeration due to their hydrophobic properties (Hongprasith et al., 2020).
Patil et al., 2023 evaluated sludge samples to determine the MPs accumulation in the treatment plant near Bhandewadi landfill site, Nagpur. The physico-chemical parameters of sewage were discussed to analyze their influence on the STP efficacy in reduction of MPs. A 5-day sampling was examined to ascertain MPs quantity (Patil et al. 2023). The study provided with treatment mechanism primary (grit, clarifier and outlet chambers), secondary (sequential batch unit), tertiary (fiber disc filter, chlorination) units comprised in STP has influent concentration 1860 ± 265 MPs/L reduced to 148 ± 51 MPs/L in effluent. This article reported primary treatment has achieved 77.99% reduction efficiency and 91.4% as total removal efficacy in STP. The MPs detached during the primary treatment eventually deposit in the sludge via., settling process. The MPs composition in the sludge amounted to 830 MPs/kg in (Patil et al. 2023), which is similar (760 particles per kg) to another study (Leslie et al. 2017). The MPs and sludge influent were immense in correspondence the effluent, indicating the efficient reduction of larger particles via., SBR technology and their settlement in sludge. These diminutive MPs can sustain suspended in the sewage, resulting hindrance in the disinfection process in tertiary treatment by creating a layer protection from pathogens to evade disinfection (Zhang and Chen 2020). The fraction of small-sized particles in the effluent is high which poses a significant environmental risk.

2. Sources and Pathways:

The primary sources of microplastics in Indian STPs include domestic wastewater, industrial discharges, and stormwater runoff. Raj et al. (2019) noted that synthetic fibers from clothing, microbeads from personal care products, and fragments from degraded larger plastic items are common contributors. These microplastics enter STPs through household drains, industrial effluents, and urban runoff, accumulating in sludge and sometimes escaping into treated effluent.
MPs with improper detoxication in STPs diffused into sludge pose a great threat when utilized in agricultural fields.(Milojevic and Cydzik-Kwiatkowska 2021).Fig. 1 has shown the path ways of Microplastics (MPs) in sludge generated in sewage treatment plants (STPs) utilized in Agriculture field (Milojevic and Cydzik-Kwiatkowska 2021).

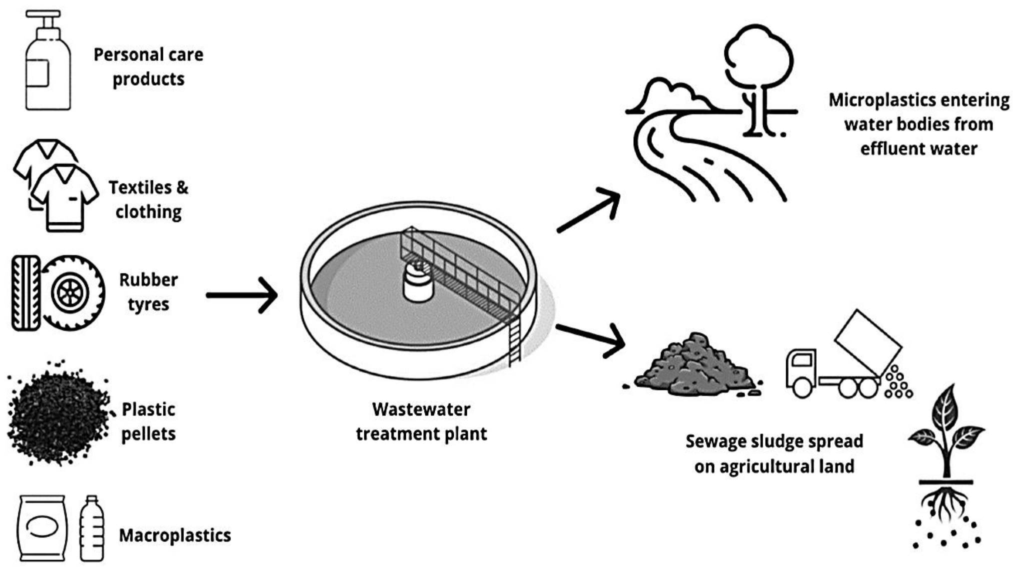

Fig. 1. – Microplastics (MPs) in sludge generated in sewage treatment plants (STPs) utilized in Agriculture field (Source: Milojevic and Cydzik-Kwiatkowska 2021).

3. Removal Efficiencies and Challenges:

The efficiency of microplastic removal in STPs varies with the technology and processes used. Conventional treatment stages like screening, sedimentation, and biological treatment can reduce microplastic concentrations but are not entirely effective. Singh et al. (2021) found that while primary and secondary treatments capture some microplastics, significant quantities remain in the final effluent and sludge. Advanced treatment processes, such as membrane bioreactors and advanced oxidation processes, show higher removal efficiencies but are not widely implemented in Indian STPs due to cost and technical complexity.

3.1. Environmental and Health Implications:

Microplastics in sewage sludge pose significant environmental and health risks. When sludge is applied as fertilizer in agriculture, microplastics can enter the soil and potentially the food chain. Chatterjee et al. (2022) discussed the potential for microplastics to cause soil contamination, affecting soil health and crop productivity. The ingestion of microplastics by soil organisms can also have cascading effects on the ecosystem.

3.2. Regulatory and Management Challenges:

The management of microplastic pollution in Indian STPs faces several challenges. There is a lack of stringent regulations and standardized methods for monitoring and controlling microplastics in sewage. Patel et al. (2020) emphasized the need for regulatory frameworks to address microplastic pollution comprehensively. Additionally, public awareness and infrastructure limitations pose significant hurdles to effective management.

4. Recommendations:

To mitigate microplastic pollution in STPs, several measures are recommended:

1. **Implementation of Advanced Treatment Technologies:** Investing in advanced treatment processes such as membrane bioreactors and advanced oxidation can enhance microplastic removal.
2. **Regulatory Frameworks:** Establishing stringent regulations and monitoring protocols for microplastics in sewage treatment is crucial.
3. **Public Awareness Campaigns:** Educating the public about the sources and impacts of microplastics can reduce their entry into sewage systems.
4. **Research and Development:** Continued research into the sources, pathways, and removal methods of microplastics is essential for developing effective strategies.

5. Conclusion:

Microplastics (MPs) pollution in sewage treatment plants (STPs) is a recurring environmental issue globally specifically in India owing to heavy-utilization of plastics. The studies reviewed highlight the significant presence of microplastics in STPs, the challenges in their removal, and the potential risks to the environment and human health. Addressing this issue requires a multi-faceted approach, including advanced treatment technologies, regulatory frameworks, public awareness, and ongoing research.

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