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The case study of Improper waste Management and Microplastics uses :- Impacts on the natural environment in India

[1]Nilimesh Majumder,[2]Aditya Ray , [3]Dr. Chandrima Goswami, [4] Monisha Hembram

[1]*Department of Environmental Studies, Rabindra Bharati University, Jorasanko campus 6/4 Dwarkanath Tagore Lane, Kolkata-700050, West Bengal, India ,*

[2]*Department of Geology, Presidency University , College square Kolkata- 700073, West Bengal India,*

[3] *Guest Faculty Department of Environmental Studies, Rabindra Bharati University, Jorasanko campus 6/4 Dwarkanath Tagore lane, Kolkata- 700050, West Bengal, India*

Abstract-

Microplastic contamination has emergedas an urgent environmental concern worldwide, and its presence in the natural environments are raising the alarms about the potential ecological consequences. The current paper has selected various mega cites of India to make a case study and aims to find out the main sources of the pollutant, their distribution patterns,the ecological impacts of Improper waste management andmicroplastics in the natural environment. Characterization of microplastics as sizes, shapes, and polymer compositions, with fibers and fragments constituting a significant portion of the observed particles on the ecosystem . so, the adsorption of chemical pollutants, microplastics and heavy metal raises concerns about their potential transfer through the food chain into the human body and subsequent ecological implications. Ecological assessments demonstrated adverse effects on aquatic biota, including ingestion by planktonic organisms and bioaccumulation in higher trophic levels. These findings underscore the need for stringent mitigation strategies to curb microplastic input into aquatic environments and emphasize the importance of further research into long-term ecological consequences.

Key word- Health issue, Improper waste Management, Sources of micro plastic contamination, Lacking of waste Management

Introduction -

Improper waste management is a major challenge to prevent the pollution, therefore the toxic heavy metals and Micro plastic are mixed with ground water and soilsurface, as a result these toxic components entered the human body through the food chain and people got many health problems so the Leaching of the solid waste into groundwater is a major environmental concern, particularly in densely populated urban areas. The improper waste management of solid waste augmented by population growth, urbanization,so the anthropogenical acitivuties has led to the rapid rise generation of municipal waste worldwide. In Indiahas been produced approximately 0.15 million tonnes of municipal solid wastedaily,total 95% of municipal solid waste is being disposed inthe landfills.soLacking ofmanagemensystemtalong the landfill siteled to the multitudeenvironmental problems such as surface wate, ground water, air and soil contamination, odorant disease-causing vector nuisance etc. In rainy season there is high chances to rainwater gets mixed with the various toxic chemicals,there fore the chemicals and materials get dissolvedon the land surface and led startto leachinginto the deep surface,and most of the leachate percolates on the ground water sources located near the dumping sites and once they reach groundwater and aquifers,The widespread contamination occurs is almost irreversible. The major pollutants are calcium, magnesium, potassium, nitrogen, and ammonia, as well as trace metals and organic compounds. This may also lead to changes in redox conditions and affect rock-water interactions. On a longer term it may change dissolution kinetics of structural minerals and affect the overall stability of the land. Areas in close proximity to landfills are particularly vulnerable to groundwater contamination, posing significant risks to local water resources and the environment. And single use plastic always scattered on the natural environment therefore micro plastic are found in aquatic species , Microplastics (MPs) are small plastic particles or fibres of size less than 5 mm, which result from the breakdown of plastics materials used in everyday life(Derraik, 2002; Wagner et al., 2014;

Eerkes-Medrano and Thompson, 2018). Their proliferation in terrestrial, marine and freshwater environments has increased dramatically in the last few decades due to the rapid rise in plastic use and its uncontrolled disposal, contributing to the accumulation of this non-degradable, hazardous waste(Dris et al., 2018; Walker, 2018). MPs can be found in soil and various other habitats like bays, estuaries, beaches, rivers, and harbours near urban centers(do Sul and Costa, 2014; Lares et al., 2018). Moreover, MPs have permeated various consumables, such as seafood, crops, salt, tap water, honey, cowmilk and even in human bodies; highlighting their widespread presence in the environment and potential impact on human health(Tanaka and Takada, 2016; Kosuth et al., 2017; Selvam et al., 2020). MPs also augment transport of toxic additives and organic pollutants through soil and water, posing significant risks to organisms and ecosystems(Boerger et al., 2010; Koelmans, 2015; Mason et al., 2016). This makes understanding and addressing microplastics a critical focus of environmental research. Over time, microplastics (MPs) undergo a series of aging processes that lead to changes in their physicochemical properties, influencing their behaviour in the environment. Initially, MPs consist of a complex mixture of high molecular polymers, along with various additives and catalysts (Teuten et al., 2009). A range of alterations, including shifts in color, chemical composition, crystallinity, surface chemistry, and sorption capacity occurs during aging. In soil, these changes occur through photo- and thermo-oxidative degradation, interactions with soil colloids(hetero-aggregation), and biodegradation by microbes(Teuten et al., 2009).

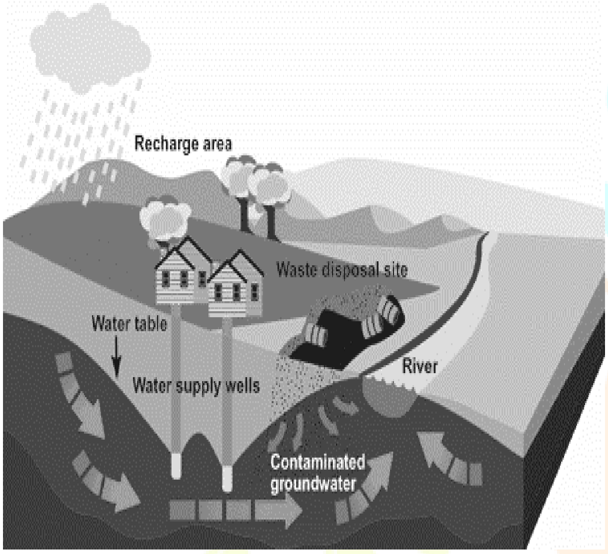


Fig. 1. A schematic diagram representing

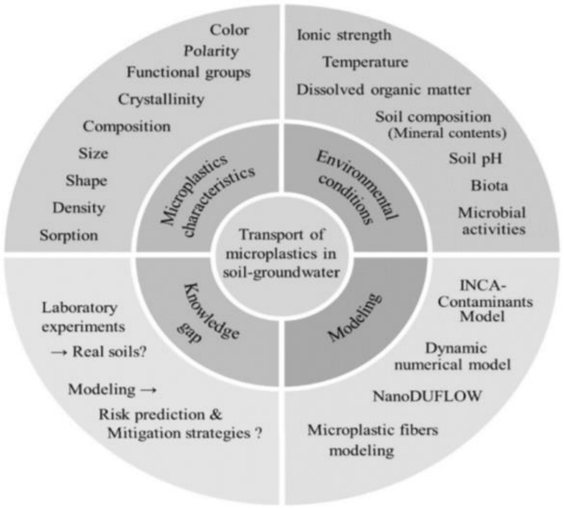


Fig. 2. Factors affecting the microplastics

The case study of Contaminated Area-

2.1The case study of New Delhi , India

The Bhalaswa landfill in Delhi has been found to significantly contaminate groundwater due to leachate from the site. An in-depth study conducted by Singh et al., reveals that contaminants such as chlorides and heavy metals are present in high concentrations in both leachate and groundwater samples taken at varying distances from the landfill. Due to the improper waste management Delhi faces more challenge to prevent the pollution , This translates to an individual waste generation rate of 500 grams per person per day, nearly five times the national average. The major sources of waste in Delhi include agricultural markets, retail/commercial markets, hospitals/nursing homes, slaughterhouses, industries, and construction/demolition activities. A large number of garbage is mixing with environment daily due to the improper disposal management,

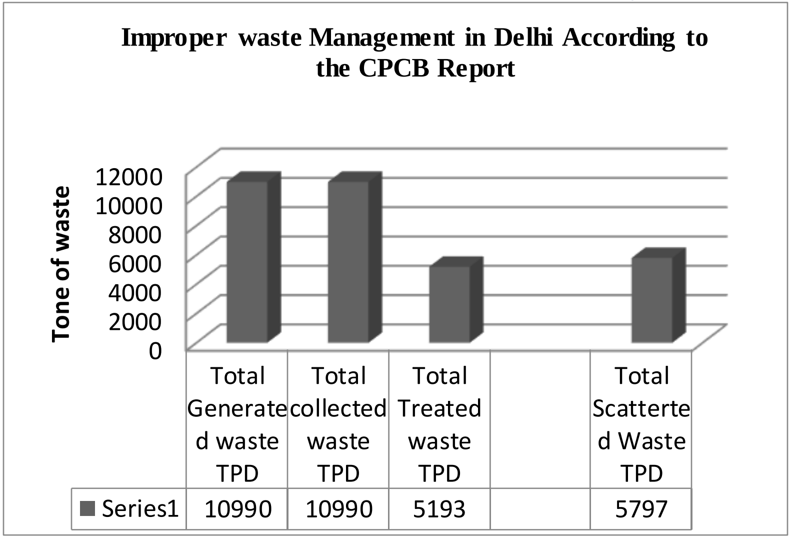


fig 3- CPCB Report Delhi

Bhalaswa sanitary landfill, situated in the northwest corner of Delhi, spans 21.06 hectares of land, with approximately 6 hectares dedicated to the compost plant. This indicates the landfill as the primary source of these pollutants, the chloride levels in landfill leachates exceed recommended limits set by the Central Pollution Control Board. Additionally, high concentrations of hazardous heavy metals like nickel, copper, and zinc are observed, believed to originate from e-waste disposal and industries. The geology of the area mainly consists of alluvium, with an unconfined aquifer system underlying the landfill site. This information underscores the urgent need for effective waste management strategies in the region. The study illustrates a typical pattern of chloride concentration in groundwater beneath the Bhalaswa landfill. Over 16 years of operation, simulated chloride levels increase, peak, and then gradually decline, reaching a maximum of 1678 mg/L, assuming a constant 2000 mg/L concentration in leachate. Currently, observed chloride concentrations within 75m of the landfill are at 1174.2 mg/L, aligning reasonably well with the simulated levels. However, as the landfill continues to grow in height without an alternative site, the total mass of leachable chloride is anticipated to rise, potentially elevating groundwater chloride concentrations to around 1000 mg/L. This poses a significant threat to the local population dependent on the contaminated water supply, particularly as water demand is projected to increase over time. The current waste disposal practices in Delhi, specifically at Bhalaswa landfill, lack environmental safeguards. Leachate from this site is heavily laden with chlorides, DOC, and COD, posing a significant risk of groundwater pollution in the vicinity. This study emphasizes the pressing need for immediate attention to safeguard the groundwater supply in this area.

2.2The case study of Gandhinagar City in Gujarat, India

The pH levels in the Gandhinagar waste site leachate varied from 7.84 to 8.98, primarily influenced by chemical reactions involving organic material degradation. This process generates carbon dioxide and small amounts of ammonia, which dissolve in the leachate, forming ammonium ions and carbonic acid. The carbonic acid then dissociates, affecting the ph. The pH range of 6.0 to 9.0 is considered safe for freshwater fish and invertebrates. In groundwater specimens, pH values ranged from 7.34 to 7.92. These variations may be attributed to factors like rainwater infiltration and dilution effects. Additionally, contaminants from natural and human activities, such as solid waste leachate percolation, can influence ph. Despite these fluctuations, the observed pH levels fell within the recommended range for drinking water (6.5-8.0). Electrical Conductivity (EC) and Total Dissolved Solids (TDS) are indicative of salinity and mineral content in the leachate. The high values of EC (4308 to 4420 µS/cm) and TDS (2760 to 2892 ppm) in the leachate sample are attributed to the presence of salts like potassium, sodium, chloride, nitrate, sulphate, and ammonia. These values exceed the recommended range for drinking water (TDS= 1653 to 1846 ppm) (EC= 1687 to 1867 µS/cm), indicating a high pollutant load. Chemical Oxygen Demand (COD) is used to indirectly measure organic compounds in water. The COD values for the collected leachate sample are notably high, ranging from 6328 to 8090 mg/L, indicating a significant presence of organic matter. In contrast, groundwater COD levels vary from 9.4 to 12.5 mg/L, suggesting a lower organic matter content. Calcium, along with magnesium, sodium, and potassium, are major cations found in leachate. Their concentrations depend on waste volume and stability stage in the landfill. Sodium and potassium are less influenced by landfill microbiological activity, possibly originating from vegetable residues and domestic waste. Elevated potassium levels in groundwater may signify leachate pollution. Calcium concentrations were notably high in both collected leachate samples (210 to 290 mg/L) and groundwater samples (120 to 167 mg/L). so the Gandhinagar waste site displayed characteristics indicative of significant organic matter content, high salinity, and mineral load. Additionally, elevated alkalinity levels suggest substantial biodegradation within disposal sites.

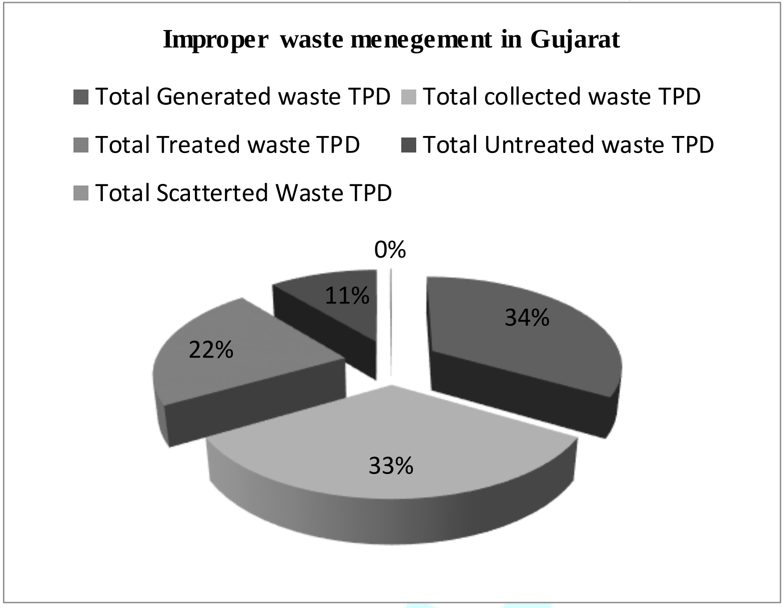


Fig 4- CPCB Report Gujarat

2.3The case study of Solapur City in Maharashtra India

The study assesses the water quality in Solapur city, Maharashtra, focusing on various parameters including ph, turbidity, total hardness, calcium, magnesium, total dissolved solids (TDS), chloride, sulphate, nitrate, and fluoride levels. The water quality assessment revealed favourableph levels ranging from 6.5 to 8.0 across six sampling stations, aligning with WHO's recommended range of 6.5 to 9.2. Turbidity, indicating fine dispersions, was notable, with values ranging from 19.4 to 28.5 NTU at seven stations. However, at GW 6, the turbidity level exceeded WHO's limit at 28.5 NTU. Total hardness fell within WHO's accepted range, ranging from 315 to 540 mg/L. Calcium and magnesium content, influencing water hardness, were within prescribed limits, with calcium ranging from 68 to 126 mg/L and magnesium from 19.5 to 75 mg/L. Total Dissolved Solids (TDS) levels, indicating salinity, varied from 465 to 1345 mg/L, with GW 1 and GW 6 surpassing WHO's recommended limit but still within allowable exceptions. Chloride content, affecting taste, ranged from 80 to 190 mg/L, all within acceptable limits. Sulphate concentrations ranged from 117 to 195 mg/L, considered safe by WHO. Nitrate levels in open well sites remained within safe limits, posing no risk. Fluoride levels, potentially causing teeth mottling, were within permissible limits even in slightly elevated levels at open well 5 (GW 5).

Overall, the study indicates that the disposal and management of municipal solid waste (MSW) in Solapur have resulted in groundwater pollution. Parameters like turbidity and MPN (not mentioned in the provided text) exceeded WHO standards. While most groundwater samples near the MSW dumping site met WHO limits, some approached permissible levels. The study recommends restricting human settlement within a minimum distance of 100m - 150m from the dumping site to mitigate potential risks associated with groundwater contamination.

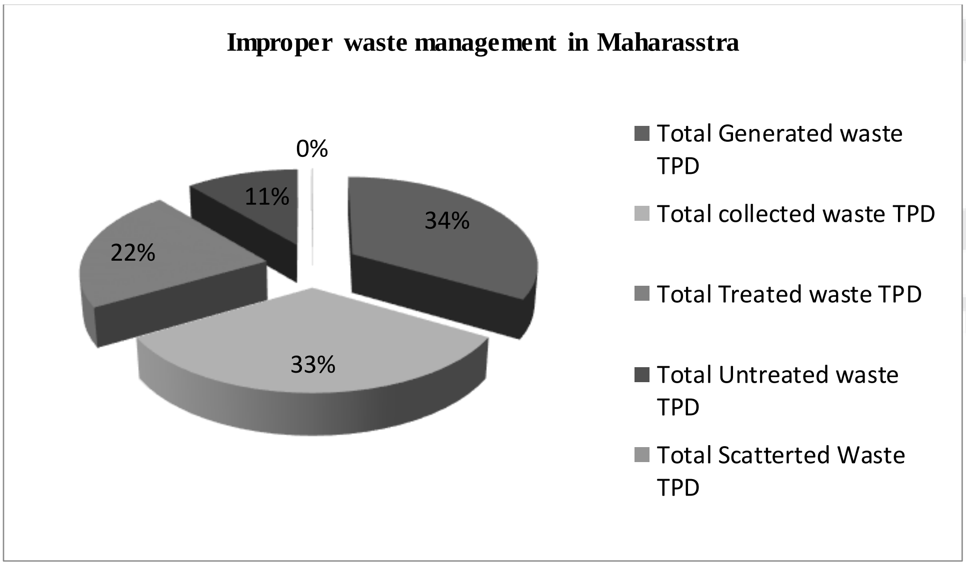


Fig 5- CPCB Report Maharashtra

2.4The case study Kolkata, West Bengal India

The Dhapa disposal site in Kolkata, India, located at 22.82°N and 88.20°E, is 26 km from Dumdum Airport. Kolkata, capital of West Bengal, experiences a tropical and rainy climate with an average temperature of 26.6°C. The city, highly populated and generating

3,000 tons of waste daily, primarily relies on three disposal sites, with Dhapa being the largest at 35 hectares. Owned by Kolkata Municipal Corporation, it consists of two unlined dumpsites, covering a total area of 35 hectares.

The leachate from the Dhapa disposal site in Kolkata exhibited distinctive physico-chemical characteristics across different seasons in 2013 and 2014. The pH levels were notably alkaline, indicating biological stabilization of organic components. Electrical Conductivity (EC) and Total Dissolved Solids (TDS) concentrations were considerably high, attributed to the presence of inorganic components, especially various anions and soluble salts. Total Hardness (TH) was likely influenced by multivalent cations like calcium and magnesium. Elevated chloride levels justified the high TDS and Chemical Oxygen Demand (COD) values, while sulphate concentration indicated the presence of different inorganic waste materials. Phosphates, potentially from various sources, were also observed. High ammoniacal nitrogen content suggested release through aerobic and anaerobic decomposition of solid waste. Leachate was heavily contaminated with organic matter, evident from high Biochemical Oxygen Demand (BOD5) and COD values. Despite high COD, heavy metals (except Hg and Pb) fell within permissible limits set by Municipal Solid Wastes Rules, 2000. Elevated levels of mercury (Hg) and lead (Pb) in the leachate indicated potential contamination sources.

Groundwater samples, assessed to gauge leachate-induced pollution, demonstrated acceptable pH levels for drinking water standards. However, Electrical Conductivity (EC) levels were notably high, suggesting elevated concentrations of anions and cations. Total Dissolved Solids (TDS) surpassed permissible limits, potentially leading to undesirable taste, odour, and colour. Total Hardness (TH) levels exceeded acceptable limits, possibly due to a faintly alkaline state. Chloride (Cl−) concentrations were also above permissible limits, likely originating from domestic effluents, fertilizers, and leachates. Sulphate (SO42-), however, remained within permissible limits, possibly influenced by sulphate-reducing bacteria activity. Among heavy metals, Hg and Pb exceeded their respective permissible limits, indicating potential groundwater contamination.Surface water samples displayed pH levels within recommended ranges for designated best use. Elevated Total Dissolved Solids (TDS) concentrations suggested pollutant leaching. Higher concentrations of sulphate ions and chloride indicated surface water contamination. Elevated Biochemical Oxygen Demand (BOD5) and Chemical Oxygen Demand (COD) levels pointed to the presence of organic matter. Lead and mercury concentrations were significantly higher in two surface water samples, further indicating potential contamination.

2.5The case study of Chennai city in Tamil Nadu India

Chennai, Tamil Nadu in India faces a mounting issue with microplastic pollution. Recent research by Ganesan et al. underscores the presence of these minuscule plastic particles, classified as primary and secondary types, in the city's groundwater, which is a primary source for drinking water. These microplastics, measuring less than 5 mm, stem from various human activities like agriculture, fishing, and household use. This contamination isn't confined to groundwater; it also extends to surface waters in industrialized zones. The study uncovered notably higher concentrations of microplastics compared to global averages, likely due to increased urban activities and effluent discharge. Significantly, polypropylene demonstrated substantial capacities for adsorbing heavy metals such as Ag, Cd, Cr, Cu, Pb, Mn, and Zn. Problems like this has been reported in several parts of India. This highlights the potential of microplastics in transporting contaminants in both surface and groundwater systems.

Due to the improper waste management heavy metal toxic components and micro plastic are leached into the soil and ground water along the landfill site and change the soil chemistry, According to the CPCB report Tami Nadu has been produced 13422 Tone of waste per day and only 12844 Tone of waste has been collected, about 9430.35 Tons of waste is treated so due to this improper waste management 3413.15 Tone of waste is not treated and 578 Tons of waste are scattered over all the Tamil Nadu

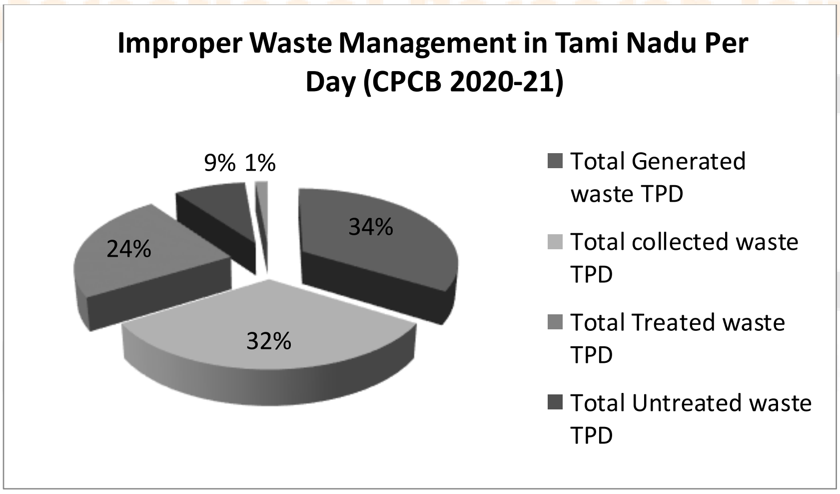
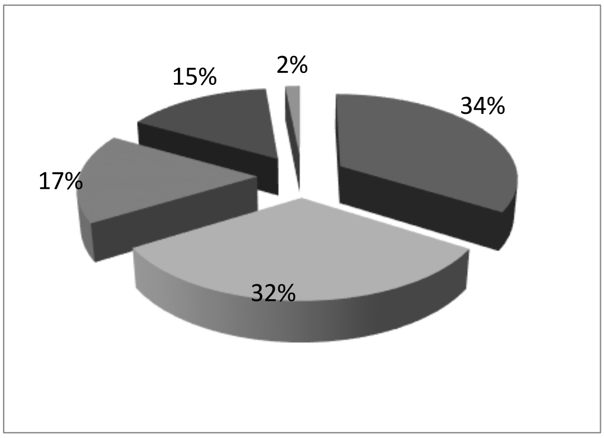


Fig-8 ImproperWaste Management in Tamil Nadu

Discussion -

The landfill site improper management is the major issue to degradation of the natural Environment, India has several larger states with high population density which directly promote urbanization and industrialization ,therefore rapid expansion of economic and population growth increasethe huge amount of waste as Municipal waste, Industrial waste and domestic solid waste. According to the CPCB Report (2020-21) Maharashtra, Uttar Pradesh West Bengal has been producing huge amount of waste,This map and figure shown the amount of garbage produced in different states of India per day

Lacking of waste Management -



Lacking of Municipal Waste Management over all the India (Tons per day) and the percentage)	
Solid waste generated (TPD)	34%
Collected of Waste (TPD)	32%
Treated of waste (TPD)	17%
Untreated of waste (TPD)	15%
Scattered of waste (TPD)	%

Fig 6- The percentage of improper waste management in India this report based on the CPCB Report (2020-21)

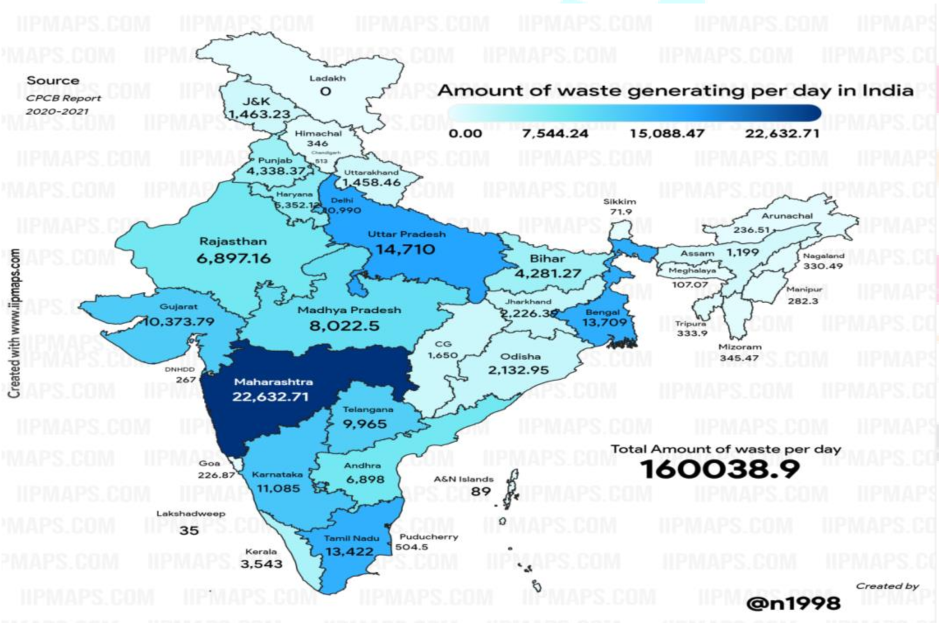


Fig 7-CPCB Report Waste generation in India

Microplastic transport in soil and leaching into groundwater:

Microplastics can enter soils through various transport processes. They may move short distances through bioturbation and agricultural practices, and longer distances via surface runoff and soil erosion (Nizzetto et al., 2016a). Soil biota activities, properties like macropores and aggregation, and practices such as plowing and bioturbation influence horizontal movement of MPs in soil (Rillig et al., 2017a,b; Rodriguez-Seijo et al., 2019). Soil can act as both a sink and potential source of microplastics, potentially contaminating groundwater and aquatic ecosystems through agricultural practices, surface runoff, and flooding (Bläsing and Amelung, 2018; Brodhagen et al., 2015; Meng et al., 2020; Wong et al., 2020; Yao et al., 2020). Microplastics smaller than soil pores can leach downward, resulting into subsoils containing higher concentrations than topsoil (Zhou et al., 2021). Studies suggest that smaller microplastics in soil may eventually reach shallow unconfined groundwater aquifers (Nizzetto et al., 2016a). Groundwater contamination by microplastics has been detected, with concentrations ranging from to7 particles per cubic meter(Panno et al., 2019; Mintenig et al., 2019). However, research on microplastic transport from soil togroundwater is still limited, presenting a pressing research area (Alimi2018)

Micro plastics as contaminant carriers:

Microplastics in soil, particularly aged particles, serve as carriers for various contaminants including heavy metals and organic pollutants. The adsorption of contaminants onto microplastics is influenced by factors like microplastic type, surface properties, and environmental conditions (pH, salinity, etc.) (Browne et al., 2013; Godoy et al., 2019; Liu et al., 2019). Heavy metals, such as Pb and Cu, strongly adhere to microplastic surfaces through electrostatic attraction and complexation (Kalčíková et al., 2020; Tang et al., 2020). Different metals exhibit varying adsorption rates based on their reactivity and ion-exchange capacity (Massos and Turner, 2017). Additionally, pH and salinity levels play pivotal roles in this adsorption process (Ahechti et al., 2020). Aged microplastics, with increasedsurface area and polarity, exhibit enhanced sorption of heavy metals (Holmes et al., 2014; Mao et al., 2020).Organic pollutants, including PAHs and pharmaceuticals, are also efficiently adsorbed by microplastics through mechanisms like π-π interactions and hydrogen bonding (Lee et al., 2014; Rochman et al., 2013a; Liu et al., 2020). Microplastic characteristics and environmental conditions significantly influence this sorption process. Polystyrene shows particularly high affinity for aromatic organic pollutants due to the presence of benzene, while polyethylene and polypropylene rely on van der Waals forces (Rochman et al., 2013b; Liu et al., 2019d). Aged microplastics with increased functional groups exhibit altered adsorption behaviour (Liu et al., 2020). Changes in pH and salinity levels further affect this interaction (Hu et al., 2020). Overall, microplastics can act as carriers, potentially leading to the co-transport of contaminants in soil environments, presenting environmental concerns (Liu et al., 2019b).

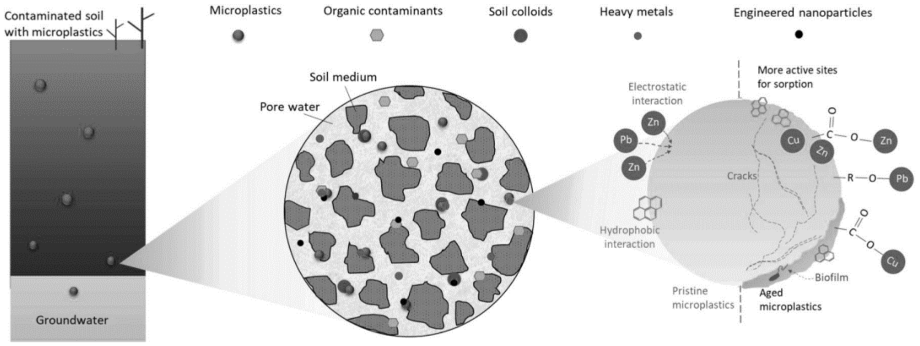


Fig. 9. Interfacial processes govern microplastic adsorption in soils. This involves interactions with soil particles, adsorbing pollutants and forming aggregates with colloids. Pure water facilitates microplastic movement. Aged microplastics, with rougher surfaces and more functional groups, enhance adsorption. Organic matter forms a biofilm, promoting further adsorption and degradation. (Ren et al., 2021)

Conclusion –

Through these case study it has been briefly discussed about the environmental concern associated with the improper waste management and Microplastics uses.So the Soil surface loss their essential nutrients and the soil concentration gradually developed, and finally the heavy metal pollute the ground water by the leaching process as exceeds their permissible limit which very harmful for the human health because the ground water is the major sources as drinking water in India. Lacking of awareness to disposal waste, the technological development, address the widespread of microplastics and heavy metal contamination along the sampled sites, with polymer types varying based on the location and anthropogenic activities. Predominant sources of microplastics include fragmentation of larger plastic debris, synthetic textiles, and microbeads from personal care products.So,this case study indicates the critical insights on the pervasiveness and diverse impacts of microplastic pollution in the environment.All the Effective management strategies mitigate this global environmental as a major challenge. So,the guidelines which has been mentioned by the Central Pollution Control Board and State Pollution Control Board shall be followed to prevent the contamination of the environment as well as awareness should be made for the reusable product to avoid the single –use plastics.

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