

Impact of Plastic Waste Leakage on Aquatic Ecosystems in Saran District

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Abstract

The leakage of plastic wastes into freshwater systems has become a significant environmental problem, especially in developing areas where waste management systems are not as effective. The present study aims to explore the effect of plastic leakage into the aquatic environment of Saran district, Bihar on pollution sources, variations throughout the year, degradation of aquatic ecosystems and deterioration of water quality. The research method used in this study was descriptive and analytical research, which was based on secondary data obtained from scientific literature, environmental reports, government publications and institutional records. The results show that household waste is responsible for 35% of the total plastic leakage and municipal drainage (28%) and commercial waste (18%). Plastic film made up 38% whilst fragments accounted for 24% of the pollutants. Seasonal analysis revealed that season of monsoon was the most polluted season because of runoff and floods that occurred. The study also noted higher levels of turbidity, higher BOD and COD levels, lower dissolved oxygen, loss of biodiversity, and micro-plastic pollution in water bodies.

Keywords: Plastic Waste, Aquatic Ecosystem, Microplastics, Water Pollution, Saran District, Waste Management.

1. Introduction

Plastic waste pollution has become one of the top environmental problems which damages aquatic ecosystems throughout the entire planet. The urban areas and rural regions experience higher plastic waste production because of three main factors which include urban expansion and industrial growth and rising plastic consumption patterns [1]. Plastic continues to exist in the environment for hundreds of years because it does not decompose and transforms into tiny particles which scientists call micro plastics. People dispose of plastic materials via incorrect methods which include open dumping, drainage channels, storm water runoff, and municipal waste leakage and these methods cause plastic waste to enter rivers and ponds and lakes and wetlands and groundwater systems [2]. Plastic waste contamination of aquatic ecosystems has become a major environmental issue which harms water quality and destroys aquatic biodiversity and disrupts ecological harmony and threatens human health [3].

In these developing areas of India, including Saran district of Bihar, plastic waste management is inadequate as the waste collection infrastructure is limited, there is no segregation and the dumped plastic wastes are not controlled around water bodies [4]. Near the riverine network of the Ganga and Gandak river system, Saran District has a large number of ponds, canals, wetlands and drainage channels which provide space for agricultural, fisheries, household and local biodiversity activities [5]. But with rising

plastic use, and poor waste management, plastic is now being leaked into waterbodies at an unprecedented rate. Common items found in open drains and water bodies are household plastics, carry bags, food packaging materials, bottles, disposable cups, and multilayered plastics [6]. These wastes are then carried into rivers and ponds during rainy and flood seasons, resulting in water pollution and degradation of the pond's ecosystem [7].

Plastic waste in aquatic ecosystems can be found in various categories such as macro-, meso-, and microplastics. Exposure to the sun, mechanical wear and tear, and biological activity can fragment large plastic pieces into microplastics less than 5 mm in size over time [8]. The particles are very persistent and hard to remove from aquatic systems. Micro-plastics have been found to be able to absorb toxic chemicals like heavy metals, pesticides, and persistent organic pollutants, which can enhance their toxicity to aquatic organisms. These can become ingested as food by fish, plankton, mollusks, crustaceans, and other aquatic species, causing injury, digestive upset, impaired reproductive ability, and/or behavioral changes [9, 10]. Additionally, these pollutants can be part of the food chain and end up in human populations that use polluted aquatic resources.

Leakage of plastic waste is also a major contributor to both physical and ecological disturbances in aquatic ecosystems [11]. Floating plastic debris impedes sunlight from entering the water, which decreases oxygen exchange between the air and the water and negatively impacts photosynthesis and productivity in aquatic habitats [12]. Additionally, plastic that has accumulated in sewers and canals can cause stagnant water, flooding, and the breeding of pathogenic organisms [13]. Furthermore, plastic pollution is changing habitat conditions for both aquatic plants and animals, thereby putting these species at risk of extinction. In India, there have been numerous studies done on freshwater ecosystems, all showing that both macro and micro plastics are accumulating in sediments, surface waters and in organisms, indicating just how serious an environmental problem this has become.

The current research will address the topic “Impact of Plastic Waste Leakage on Aquatic Ecosystems in Saran District” in order to analyze the level, origin, and environmental implications of plastic pollution in the water bodies of Saran District. The research will assess the ways that plastic wastes leak into aquatic ecosystems and their impact on water bodies and aquatic organisms in particular. Additionally, it is necessary to reveal the contribution of human activities, waste disposal from municipalities, and seasonal changes to the leakage of plastics in local water bodies. Such knowledge will be important for the development of appropriate waste management methods, awareness campaigns, and environmental protection policies.

The research is highly relevant since the health and functioning of aquatic ecosystems contribute greatly to the ecological balance of nature, fishery activities, replenishment of groundwater, and welfare of local residents. The constant presence of plastic waste may have devastating effects on both the environment and people. Thus, the scientific assessment and proper management of plastic waste leakage is an urgent task in the region.

2. Literature Review

There is a large body of literature available which emphasizes the leakage of plastic waste and the presence of micro plastics in freshwater and aquatic environments globally. Mandal et al. (2025) [14] studied the presence and ecological hazards of MPs in urban ponds and rivers of eastern India, and reported high levels of MPs in the surface water and sediments, with nylon and polyethylene being the prevalent

polymers. Likewise, Khan et al. (2026) [15] discussed the plastic pollution in the river of Karnaphuli in Bangladesh and highlighted the significant sources of macro plastic pollution to the river as urban runoff, domestic wastes, and pluvial flow during rainfall. Prasad et al. (2025) [16] discussed the rising plastic waste problem in India and stated that the improper management of plastic waste and surge in single-use plastic has led to environmental degradation in the country, including rivers, fisheries, and public health issues. Pandey et al. (2023) [17] highlighted the detection of micro-plastics in the edible parts of freshwater fishes, thus indicating the transfer of plastic particles into aquatic food chain and concerning the human exposure via fish consumption. Similarly, Masood et al. (2024) [18] summarized the impacts of marine plastic pollution on the environment, stating that plastic waste leads to habitat disruption, toxicological effects, reproductive issues, and biodiversity and food web disruptions in the marine environment. These studies collectively show that the risk of plastic waste leakage is serious for aquatic animals, water quality, ecosystem stability and human health.

A few review papers have also contributed to the knowledge of the presence of microplastics in Indian inland aquatic systems. Neelavannan et al., (2023) [19] did a detailed survey of microplastic contamination in Indian rivers and lakes and found that most of the detected freshwater systems were having a presence of polypropylene, polyethylene terephthalate and polyethylene. Singh et al. (2024) [20] stressed that seasonal and hydrological variability plays a significant role in the distribution of microplastics in inland aquatic systems and also indicated that hydrological data should be combined with pollution studies to assess contamination pathways.

Villarrubia-Gómez et al. (2022) [21] took a global perspective on plastic pollution and stated that plastics are not just harmful for the environment due to pollution, but also to climate change and biodiversity loss, and that they have already surpassed the environmental limits on earth. Jaiswal et al., (2025) [22] investigated seasonal microplastic pollution in Man Sagar Lake and concluded that the abundance of microplastic was found to be maximum during post-monsoon where the rainfall and runoff play a major role in carrying plastic waste into the aquatic environment. Moreover, one of the earliest studies on baseline data of the rivers of South India was done by Lechthaler et al. (2021) [23] where the researchers found the concentration of microplastics in urban rivers is higher than that in rural rivers, thereby showing the impact of urbanization and anthropogenic activities on freshwater pollution.

Overall, the studies highlight the dire ecological, toxicological, and socio-economic consequences of plastic pollution and emphasize the need for proactive waste management measures, increased awareness, and localized mitigation strategies. Although a lot of research has been conducted on plastic pollution in aquatic systems, only a few studies have been conducted in freshwater bodies in Bihar especially Saran district. Previous studies have focused on marine environments, urban rivers, and large lakes; with little attention given to rural ponds, canals, and local drainage and disposal systems. Furthermore, there is a lack of information about the seasonal release of plastic waste, the effect of plastic waste on the life of aquatic organisms in the local area, and the connection between waste disposal and water pollution. Hence, urgent need for region-specific assessment and sustainable mitigation strategies are needed in Saran District.

3. Research Methodology

The methodology has been designed to examine the extent of plastic pollution, its sources, ecological consequences, and associated environmental risks affecting aquatic ecosystems. The research focuses on

analyzing existing scientific data which includes governmental and institutional information to evaluate the current condition of aquatic ecosystems in Saran District because plastic waste leakage has developed into a significant environmental problem that affects both urban and rural areas. The research methodology provides a structured framework for identifying, collecting, organizing, and interpreting relevant information regarding plastic pollution and aquatic environmental degradation. The methodology enables researchers to acquire knowledge about current waste management methods and existing pollution patterns together with the environmental problems that arise from plastic waste which accumulates in freshwater environments.

3.2 Research Design

The current research project uses a descriptive research design together with an analytical research design. The research utilizes a descriptive method to examine plastic waste leakage into aquatic ecosystems while the analytical method assesses the plastic pollution damage to water quality and aquatic biodiversity and ecosystem sustainability. The research combines both qualitative and quantitative methods because it involves analyzing environmental conditions and pollution patterns while using numerical data from published reports and scientific studies and environmental records. The research investigates seasonal patterns together with ecological dangers and plastic pollution waste management challenges in freshwater ecosystems.

3.3 Nature of the Study

The research mainly relies on secondary data collection techniques. Using secondary data allows the researchers to conduct an all-round study of the trends and effects of plastic pollution in aquatic environments without undertaking any field work. The investigation delves into the possible sources of plastic waste that cause pollution in aquatic environments, such as waste disposal at households, urban runoff, drainage discharges, commercial operations, and improper solid waste management. The study also focuses on the different types and features of plastic pollution, which include macroplastics and microplastics and their physical properties like size, shape, and polymer type.

Moreover, the research analyzes the impact of plastic waste on freshwater ecosystems through its effects on water quality, aquatic species, biodiversity, and general ecosystem integrity. The study also assesses the implications of plastic waste on the environment by focusing on microplastic pollution and its impacts, such as food chain contamination, habitat destruction, and potential effects on human health. The researchers also evaluate the current waste management strategies, environmental policies, and measures to mitigate plastic pollution in freshwater ecosystems. Besides, the research will analyze the seasonal effects, precipitation rates, urbanization, and other anthropogenic activities contributing to plastic pollution in aquatic environments.

3.4 Study Area

The current research work will concentrate on Saran District of Bihar, India, which consists of various rivers, ponds, canals, wetlands, and drainages that hold environmental and economic significance for the people living nearby. The increase in urbanization, population growth, and poor practices of waste management have led to the leakage of plastic waste into the aquatic environment. The present research location was chosen due to an increasing amount of exposure of water sources in this area to municipal

solid waste, drainage waste, and plastic waste produced by households, industries, and agriculture. The research will be conducted using the available secondary data.

3.5 Data Analysis Method

The collected secondary data were systematically organized, classified, and analyzed using descriptive and comparative methods. Information obtained from different studies and reports was compared to identify patterns, trends, and environmental impacts associated with plastic waste leakage.

The analysis included:

- Comparison of findings from previous research studies
- Evaluation of plastic pollution trends
- Interpretation of ecological impacts on aquatic ecosystems
- Assessment of environmental risks associated with microplastics
- Analysis of waste management practices and policy measures

4. RESULTS AND ANALYSIS

4.1 Sources of Plastic Waste Leakage

Plastic waste enters aquatic ecosystems through multiple anthropogenic activities such as domestic waste disposal, market waste, drainage discharge, agricultural runoff, and improper municipal waste management practices.

Table 4.1: Major Sources of Plastic Waste Leakage in Aquatic Ecosystems

S. No.	Source of Plastic Waste	Major Plastic Materials	Environmental Impact
1	Household Waste	Plastic bags, bottles, packaging materials	Water contamination and blockage of drains
2	Market and Commercial Waste	Food wrappers, disposable cups and plates	Increased surface pollution in ponds and canals
3	Municipal Drainage	Mixed plastic litter and sewage waste	Transport of plastics into rivers and wetlands
4	Agricultural Activities	Fertilizer bags, irrigation pipes	Soil and water contamination
5	Religious and Recreational Activities	Decorative plastic items and packaging	Floating debris and habitat disturbance
6	Open Dumping Near Water Bodies	Mixed municipal plastic waste	Direct leakage into aquatic ecosystems

Household and municipal waste are significant contributors to the overall annual inputs of plastic pollution into aquatic ecosystems, according to Table 4.1 findings and observations. When single-use plastics are not disposed of properly, or when there is no waste segregation, plastic debris accumulates in nearby ponds, canals and rivers. Plastic waste accumulates in freshwater bodies through drainage systems, which are the conduit for plastic pollution entering freshwater bodies, particularly during rainfall and flooding events.

Major sources of plastic waste entering aquatic ecosystems in the Saran District are displayed in Figure 4.1. The largest contributor to plastic pollution in aquatic ecosystems is household waste (35% of total

plastic), followed by municipal drainage (28% of total plastic pollution), and commercial (18% of total plastic pollution) waste. Agricultural activities account for 10% of total plastic pollution, and religious activities account for 5% of total plastic pollution. Open dumping of plastic waste near water bodies accounts for just 4% of total plastic pollution. The data suggests that the failure of domestic and municipal waste management systems are the principal reasons for plastic pollution in freshwater ecosystems.

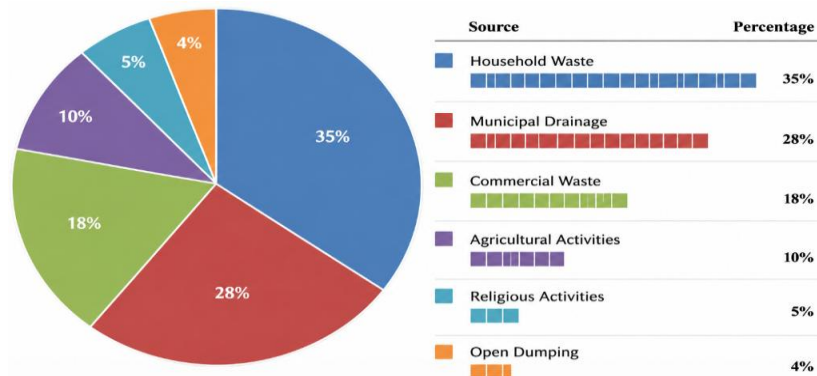


Figure 4.1 Major Sources of Plastic Waste Leakage

4.2 Types and Characteristics of Plastic Pollutants

Plastic pollutants found in freshwater ecosystems are generally categorized based on shape, size, and polymer type.

Table 4.2: Distribution of Plastic Pollutants in Aquatic Ecosystems

Type of Plastic Pollutant	Percentage (%)	Major Characteristics
Plastic Films	38	Thin carry bags and wrappers
Plastic Fragments	24	Broken plastic pieces
Fibers	15	Synthetic textile fibers
Pellets	10	Industrial plastic particles
Foam Materials	7	Thermocol and packaging foam
Bottles and Containers	6	Large floating plastic waste

Table 4.2 shows that plastic films and fragments serve as the primary plastic waste type which pollutes water environments. The materials originate from activities conducted in both residential and business settings. The discovery of microplastic fibers demonstrates that household wastewater and textile waste materials have contaminated the area. Floating debris includes foam materials and plastic bottles, which decrease the visual appeal and ecological health of water bodies.

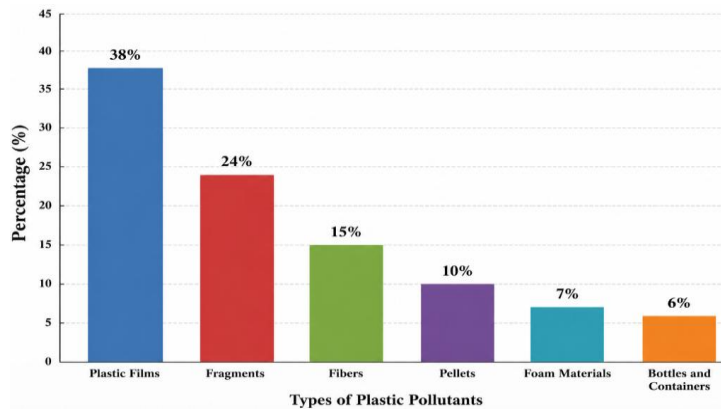


Figure 4.2 Distribution of Plastic Pollutants

The percentage composition of plastic pollutants detected in Saran District’s aquatic ecosystems is shown in Figure 4.2 below. The largest number of plastics (38%) comprises films, with fragments comprising 24% and fibers comprising 15% of all the plastic pollutants. Only 10% of plastic pollutants detected comprise pellets, while foam plastics make up 7%. Bottles/containers account for only 6% of all the plastic pollutants. This figure suggests that the dominant plastics are those which are easily disposed of through packaging waste.

4.3 Seasonal Variation in Plastic Waste Leakage

Seasonal changes significantly influence the transport and accumulation of plastic waste in aquatic ecosystems.

Table 4.3: Seasonal Variation in Plastic Pollution Levels

Season	Estimated Plastic Pollution Level	Major Causes
Pre-Monsoon	Moderate	Dry waste accumulation near drains
Monsoon	Very High	Rainfall runoff and flooding transport plastics into rivers and ponds
Post-Monsoon	High	Residual plastic accumulation in sediments and banks
Winter	Moderate	Reduced water flow and localized waste deposition

The monsoon season recorded the highest level of plastic waste leakage due to heavy rainfall and surface runoff seen in table 4.3. Urban and rural areas experience floodwaters which carry away plastics that people have improperly disposed into nearby aquatic ecosystems. Post-monsoon periods also show significant accumulation because plastics remain trapped in sediments and along riverbanks.

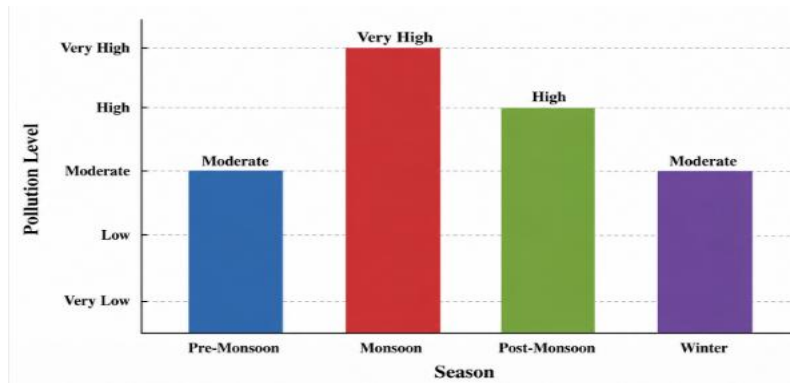


Figure 4.3 Seasonal Plastic Pollution Levels

Plastic pollution levels in aquatic systems in Saran district are presented in Figure 4.3 according to their seasonal variations. The monsoon season displays the peak level of plastic pollution owing to rainwater, surface runoff, and flooding, which carry plastics to rivers, lakes, and drains. Pollution levels are also high during post-monsoon periods, since plastics persistently accumulate in sediments and along waterways. The pre-monsoon and winter seasons display moderate levels of pollution, resulting from local deposition of wastes and low water flow.

4.4 Impact of Plastic Waste on Water Quality

Plastic waste pollution affects the physicochemical properties of freshwater ecosystems and contributes to ecological degradation.

Table 4.4: Comparative Analysis of Water Quality Parameters

Parameter	Normal Range	Observed Condition in Polluted Water Bodies	Environmental Impact
pH	6.5 – 8.5	Slightly acidic to neutral	Disturbance in aquatic metabolism
Dissolved Oxygen (DO)	5 – 8 mg/L	Reduced	Stress on aquatic organisms
Biological Oxygen Demand (BOD)	<3 mg/L	Increased	High organic and waste pollution
Chemical Oxygen Demand (COD)	<10 mg/L	Increased	Presence of chemical contaminants
Turbidity	Low	High	Reduced sunlight penetration
Total Dissolved Solids (TDS)	<500 mg/L	Elevated	Water quality deterioration

Table 4.4 shows that accumulation of plastics negatively impacts the water quality parameters listed in the table. Increased turbidity and decreased levels of dissolved oxygen in water are typical characteristics of a water body that is contaminated with leaks from pollutants. High BOD and COD levels indicate that there is an organic/bio-chemical contaminant present, likely in relation to the plastic waste, and that it is affecting the quality of the way in which the aquatic organisms and their ecosystem operate.

4.5 Ecological Impacts of Plastic Pollution

Plastic waste leakage causes severe ecological disturbances in freshwater ecosystems.

Table 4.5: Ecological Impacts of Plastic Waste on Aquatic Ecosystems

Ecological Component	Observed Impact
Aquatic Flora	Reduced photosynthesis due to floating plastics
Fish and Aquatic Fauna	Ingestion of microplastics and habitat disturbance
Water Birds	Risk of entanglement and ingestion
Sediment Quality	Accumulation of microplastics in bottom sediments
Biodiversity	Decline in sensitive aquatic species
Food Chain	Transfer of microplastics to higher trophic levels

According to the results of table 4.5, water pollution caused by plastics negatively impacts the diversity of aquatic life and disrupts the stability of the ecosystem. As floating plastics block light from reaching the water surface, aquatic plant photosynthesis is affected, leading to lower rates of primary production (productivity from phytoplankton). Additionally, the ingestion of microplastics by fish and other aquatic organisms may result in internal injuries, reproductive issues, and contamination of the food chain. Over time, the accumulation of plastics in water will change the sediment characteristics and disrupt the ecological balance.

4.6 Existing Waste Management Practices

Waste management plays a crucial role in controlling plastic waste leakage into aquatic ecosystems.

Table 4.6: Existing Plastic Waste Management Practices in Saran District

Waste Management Practice	Current Status	Effectiveness
Door-to-Door Waste Collection	Limited coverage	Moderately Effective
Waste Segregation	Poor	Low Effectiveness
Recycling Facilities	Insufficient	Limited Impact
Awareness Programs	Occasional	Moderate Awareness
Ban on Single-Use Plastics	Partially Implemented	Low Compliance
Municipal Waste Disposal	Inadequate	Major Source of Leakage

The analysis in table 4.6 shows that existing waste management systems in the region are insufficient to control plastic pollution effectively. Lack of waste segregation, limited recycling facilities, and poor implementation of plastic regulations contribute to increasing leakage of plastic waste into aquatic ecosystems.

4.7 Discussion of Findings

As per the results obtained from the current study, plastic waste leakage has emerged as one of the major environmental problems in aquatic environments within the Saran district. Urbanization, increase in population, excessive use of single-use plastics, and poor waste management have been considered as the main factors leading to plastic pollution in water. Household garbage, municipal drainage discharge, market garbage, open dumping of plastic waste, and rainwater runoff were identified as the major sources

that contribute to the entry of plastic waste into water bodies. Plastic films, fragments, fibres, and plastics used for packaging purposes were considered as the main types of pollutants, since these kinds of disposable plastic products are widely used and not recycled properly. It is evident from the results obtained from seasonal studies that the monsoon season contributes to the high level of plastic pollution because of rain and flooding that bring large amounts of plastic waste into aquatic environments.

The study also brings to the fore the dire ecological and environmental consequences of plastic waste in the environment. The accumulation of plastic has a negative impact on water quality by introducing increased turbidity, biological oxygen demand (BOD) and chemical oxygen demand (COD) that reduce dissolved oxygen levels that are vital to the survival of aquatic life. Floating plastics block sunlight, interrupt the productivity and ecological balance of the aquatic environment. Furthermore, microplastics are a very serious threat for aquatic life due to ingestion, disturbance of the habitat and contamination of the food chain. It also finds that the current waste management system in Saran District is weak and ineffective because waste is not properly sorted, waste recycling facilities are limited and plastic control measures are not well implemented. Thus, the adoption of appropriate waste management practices, raising awareness and enforcing regulations are vital in minimizing plastic waste and safeguarding water bodies.

5. Conclusion

Based on the present study, it is concluded that the leakage of plastic waste is a serious problem of environmental concern, which is affecting the aquatic ecosystem in Saran District, Bihar. With the rapid urbanization and population growth, plastic pollution has been a serious problem in rivers, ponds, canals, wetlands and drainage areas, due to improper waste management practices and excessive use of single-use plastics. Household waste was found to be the biggest contributor of plastic leakage, followed by municipal drainage and commercial activities. The most prevalent pollutant in aquatic ecosystems was plastic films and fragments, which suggests a widespread use of disposable plastic and inadequate recycling.

The study also found that the level of plastic pollution is higher during the monsoon season because of the rain and flooding conditions which cause significant runoff of plastic waste into freshwater bodies. There were signs of deterioration in the quality of water such as increase in turbidity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and decreased Dissolved Oxygen (DO). Aquatic biodiversity was found to be negatively impacted by plastic pollution, especially via the degradation of habitats and the presence of microplastics. This research also reveals the need for better waste management systems, recycling facilities, public awareness programs, and environmental laws to curb plastic pollution and safeguard aquatic life in Saran District.

References

- [1] Mihai, Florin-Constantin, Sedat Gündoğdu, Laura A. Markley, Arianna Olivelli, Farhan R. Khan, Claire Gwinnett, Jutta Gutberlet et al. "Plastic pollution, waste management issues, and circular economy opportunities in rural communities." *Sustainability* 14, no. 1 (2021): 20.
- [2] Nnoko, Joles Epie. "Assessing the Impacts of Plastic Waste Pollution in Exacerbating Urban Flooding in Douala." (2024).

- [3] Kumar, Rakesh, Anurag Verma, Arkajyoti Shome, Rama Sinha, Srishti Sinha, Prakash Kumar Jha, Ritesh Kumar et al. "Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions." *Sustainability* 13, no. 17 (2021): 9963.
- [4] Bharat, Girija K., Avanti Roy Basu, Abdullah Atiq, Emmy Nøklebye, Ingvild Skumlien Furuset, Twinkle Dev, and Hans N. Adam. "Regulatory Framework, Policies, and Programs in Plastic Waste Management: Global and Indian." In *Efficient and Enhanced Management of Plastic Waste in India: Case Studies from Vapi and Surat*, pp. 179-214. Cham: Springer Nature Switzerland, 2025.
- [5] Joshi, Kripal Datt, Ajey Kumar Pathak, Santosh Kumar, Rajesh Dayal, Ajay Kumar Singh, Ravi Kumar, G. Kantharajan, Vindhya Mohindra, and Kuldeep K. Lal. "Fish community diversity assessment of protected Saraiyaman wetland in the Ganga River basin, India." *Community Ecology* 23, no. 1 (2022): 63-73.
- [6] Blettler, Martin CM, Maria Alicia Ulla, Ana Pia Rabuffetti, and Nicolás Garello. "Plastic pollution in freshwater ecosystems: macro-, meso-, and microplastic debris in a floodplain lake." *Environmental monitoring and assessment* 189, no. 11 (2017): 581.
- [7] Ozoh, A. N., B. T. Longe, V. Akpe, and I. E. Cock. "Indiscriminate solid waste disposal and problems with water-polluted urban cities in Africa." *Journal of Coastal Zone Management* 24, no. S5 (2021): 1000005.
- [8] Sun, Jiaoxia, Hanyue Zheng, Hong Xiang, Jianxin Fan, and Hui Jiang. "The surface degradation and release of microplastics from plastic films studied by UV radiation and mechanical abrasion." *Science of the Total Environment* 838 (2022): 156369.
- [9] Ali, T. A. Y. Y. A. B. A., T. A. Y. Y. A. B. A. Shakeel, F. A. R. K. H. A. N. D. A. Asad, and A. S. M. A. Ashraf. "Water quality and fish health: Interaction with toxic substances." *Zoology: Advancements and Research Trends* (Ijaz MU, N Ehsan, M Imran & S Yousaf, eds): FahumSci, Lahore, Pakistan (2024): 215-221.
- [10] Vo, Huu Cong, and Minh Hen Pham. "Ecotoxicological effects of microplastics on aquatic organisms: a review." *Environmental Science and Pollution Research* 28, no. 33 (2021): 44716-44725.
- [11] Isangedighi, Isangedighi Asuquo, Gift Samuel David, and Ofonmbuk Ime Obot. "Plastic waste in the aquatic environment: impacts and management." In *Analysis of nanoplastics and microplastics in food*, pp. 15-43. CRC Press, 2020.
- [12] Chen, Xianchuan, Xiong Xiong, Xiaoming Jiang, Huahong Shi, and Chenxi Wu. "Sinking of floating plastic debris caused by biofilm development in a freshwater lake." *Chemosphere* 222 (2019): 856-864.
- [13] Vincent, Savariar. "International Journal of Waste Resources." (2014).
- [14] Mandal, Mamun, Anamika Roy, and Abhijit Sarkar. "Comprehensive study of the microplastic footprint in the urban pond and river of Eastern India." *Scientific Reports* 15, no. 1 (2025): 8645.
- [15] Khan, Ariful Anwar, Sreebash Chandra Bhattacharjee, Masuma Wahab, Joy Bardhan, Puja Bhattacharjia, Abu Hena Sajib, Abdul Kader, and Abdul Hasib Mollah. "Assessing the Health of Karnaphuli River, Bangladesh: A Comprehensive Study of Macro Plastic Pollution, Water Quality, and Community Perspectives."
- [16] Prasad, Girija, Himalaya S. Vardikar, Abdullah Atiq, Smita Mohanty, Twinkle Dev, Avanti Roy Basu, Suneel Pandey, Girija K. Bharat, and S. K. Nayak. "Status of Litter and Plastic Pollution Globally



and in India." In *Efficient and Enhanced Management of Plastic Waste in India: Case Studies from Vapi and Surat*, pp. 1-48. Cham: Springer Nature Switzerland, 2025.

[17] Pandey, Namrata, Rahul Verma, Satyakam Patnaik, and Sadasivam Anbumani. "Abundance, characteristics, and risk assessment of microplastics in indigenous freshwater fishes of India." *Environmental Research* 218 (2023): 115011.

[18] Masood, Sadaf, Wajid Ali, Mahnoor Iftikhar, Furqan Khan, Ameer Hassan, Ashique Ali Chohan, and Aqsa Sarwar. "Marine plastic pollution: Impacts on aquatic fauna and ecosystem health." *The Research of Medical Science Review* 2, no. 3 (2024): 815-831.

[19] Neelavannan, Kannaiyan, and Indra Sekhar Sen. "Microplastics in freshwater ecosystems of India: current trends and future perspectives." *ACS omega* 8, no. 38 (2023): 34235-34248.

[20] Singh, Jaswant, Brijesh K. Yadav, Uwe Schneidewind, and Stefan Krause. "Microplastics pollution in inland aquatic ecosystems of India with a global perspective on sources, composition, and spatial distribution." *Journal of Hydrology: Regional Studies* 53 (2024): 101798.

[21] Villarrubia-Gómez, Patricia, Bethanie Carney Almroth, Morten Walbech Ryberg, Marcus Eriksen, and Sarah Cornell. "Plastics pollution and the planetary boundaries framework." *Plastics Pollution and the Planetary Boundaries framework* Patricia Villarrubia-Gómez,* a Bethanie Carney Almroth, b Marcus Eriksen, c Morten Ryberg, d, e and Sarah E. Cornell, a a Stockholm Resilience Centre, Stockholm University, SE-106 91 (2022).

[22] Jaiswal, Prashant Kumar, Vrinda Vijayan, Sanjeev Kumar, Rajesh Kumar, and Ritu Singh. "Seasonal distribution of microplastics and associated ecological risks in a semi-arid freshwater ecosystem in India." *Environmental Pollution* 376 (2025): 126430.

[23] Lechthaler, Simone, Kryss Waldschläger, Chavapati Gouse Sandhani, S. A. Sannasiraj, V. Sundar, Jan Schwarzbauer, and Holger Schüttrumpf. "Baseline study on microplastics in Indian rivers under different anthropogenic influences." *Water* 13, no. 12 (2021): 1648.