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The Effect of Plastic Pollution on The Fresh Water Ecosystem

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Abstract- Plastic pollution has emerged as a significant environmental challenge affecting freshwater ecosystems globally. This study investigated the effects of plastic pollution on freshwater ecosystems by assessing microplastic contamination and selected water quality parameters across different sampling sites exposed to varying levels of anthropogenic activities. A quantitative and descriptive research design was employed to evaluate the distribution, abundance, and ecological impacts of microplastics in freshwater environments. Water, sediment, and biological samples were collected using standardized sampling and laboratory procedures to identify and quantify plastic particles. Key physicochemical parameters, including dissolved oxygen, pH, and turbidity, were also analyzed to determine the relationship between plastic pollution and water quality. The findings revealed considerable spatial variation in microplastic concentration among the sampling sites. Highly urbanized and industrialized areas recorded elevated levels of contamination, with the highest concentration observed at Site F (390 particles/L), followed by Site C (340 particles/L). Sites with increased microplastic abundance also exhibited lower dissolved oxygen levels, higher turbidity, and slight reductions in pH, indicating ecological stress and deterioration of water quality. The study further showed that microplastics persist in freshwater environments and pose serious risks to aquatic organisms through ingestion, habitat alteration, and toxic chemical transfer within aquatic food webs. The study concludes that plastic pollution significantly threatens freshwater ecosystem health and biodiversity. Effective waste management strategies, environmental regulations, and continuous monitoring programs are therefore essential to reduce plastic contamination and protect freshwater resources.

Keywords- Plastic Pollution; Freshwater Ecosystem; Microplastics; Water Quality; Aquatic Biodiversity; Environmental Contamination; Dissolved Oxygen.

I. INTRODUCTION

Plastic pollution has emerged as one of the most critical environmental challenges affecting freshwater ecosystems worldwide. The rapid increase in plastic production, coupled with poor waste management practices and excessive consumption of single-use plastics, has resulted in the accumulation of plastic debris in rivers, lakes, wetlands, and streams (Azevedo-Santos et al., 2021). Freshwater ecosystems serve as essential habitats for aquatic organisms, provide drinking water, support agriculture, and maintain ecological balance. However, the continuous discharge of plastic waste threatens the structure and function of these ecosystems by altering water quality, disrupting food chains, and affecting biodiversity.

Plastics enter freshwater environments through multiple pathways, including urban runoff, industrial discharge, domestic sewage, agricultural activities, and improper disposal of solid waste (Blettler et al., 2018). Over time, larger plastic materials degrade into smaller particles known as microplastics, usually less than 5 mm in size, which are now recognized as major contaminants in aquatic ecosystems (Strungaru et al., 2019). These microplastics can persist for long periods because of their resistance to biodegradation, allowing them to accumulate in sediments and water bodies. Their small size also enables ingestion by aquatic organisms such as fish, zooplankton, mollusks, and benthic invertebrates, thereby posing significant ecological and toxicological risks.

Research has shown that plastic pollution negatively affects freshwater biodiversity by causing physical injuries, intestinal blockage, reduced feeding efficiency, and reproductive disorders in aquatic organisms (Bellasi et al., 2020). In addition, plastics can absorb toxic chemicals such as pesticides, heavy metals, and persistent organic pollutants from surrounding water, acting as carriers of harmful substances into aquatic food webs (Mendoza & Balcer, 2019; Barwant et al., 2025). The bioaccumulation of these pollutants may eventually affect human health through the consumption of contaminated fish and water resources.

Freshwater ecosystems are particularly vulnerable because rivers and lakes act as transport pathways that carry plastic waste from terrestrial environments to marine ecosystems (Chen et al., 2021). Despite increasing global attention on marine plastic pollution, freshwater systems have historically received less scientific focus, resulting in significant knowledge gaps regarding the distribution, sources, and ecological impacts of plastics in inland waters (Blettler et al., 2019). Recent studies indicate that microplastic contamination is rapidly increasing in freshwater environments across both developed and developing countries, making it a growing environmental concern (Sarijan et al., 2021).

Furthermore, plastic pollution contributes to habitat degradation and ecosystem imbalance by affecting nutrient cycling, sediment composition, and microbial communities within freshwater habitats (Kumar et al., 2022; Singh et al., 2026; Singh, 2026). The accumulation of plastic debris along shorelines and riverbeds can also reduce oxygen exchange, alter light penetration, and interfere with aquatic vegetation growth. These impacts collectively threaten ecosystem services that freshwater environments provide to both humans and wildlife.

Given the ecological, economic, and public health implications of plastic contamination, understanding the effects of plastic pollution on freshwater ecosystems is essential for developing effective management strategies and environmental policies. Therefore, this study aims to examine the sources, distribution, and ecological impacts of plastic pollution in freshwater ecosystems, with particular emphasis on the effects of microplastics on aquatic organisms and water quality.

II. METHODOLOGY

Research Design

This study adopted a quantitative and descriptive research design to investigate the effects of plastic pollution on freshwater ecosystems. The research focused on assessing the occurrence, distribution, and ecological impacts of plastic waste, particularly microplastics, in selected freshwater bodies such as rivers, lakes, and streams. Quantitative methods were employed to measure the concentration of plastic debris in water and sediment samples, while observational techniques were used to evaluate the effects on aquatic organisms and water quality parameters.

Study Area

The study was conducted in selected freshwater ecosystems exposed to varying levels of anthropogenic activities, including urban settlements, agricultural areas, and industrial zones. Sampling locations were selected based on their proximity to potential sources of plastic pollution such as drainage outlets, waste disposal sites, fishing areas, and recreational zones. Both polluted and relatively less disturbed sites were included to allow comparative analysis of contamination levels and ecological effects.

Sample Collection

Water, sediment, and biological samples were collected using standardized freshwater microplastic sampling procedures recommended in previous studies (Razeghi et al., 2021). Surface water samples were obtained using stainless steel buckets and plankton nets with mesh sizes ranging from 300 µm to 500 µm to capture floating plastic particles (Campanale et al., 2020). Sediment samples were collected using grab samplers from the riverbed or lake bottom and stored in clean glass containers to avoid contamination.

Biological samples such as fish and aquatic invertebrates were also collected to examine the ingestion and accumulation of microplastics within aquatic organisms. All samples were labeled, sealed, and transported to the laboratory for analysis following contamination prevention protocols, including the use of cotton laboratory clothing and non-plastic equipment whenever possible (Stock et al., 2019).

Laboratory Analysis

In the laboratory, samples underwent filtration, density separation, and digestion processes to isolate plastic particles from organic matter and sediments. Sodium chloride (NaCl) solution was used during density separation because of its effectiveness in extracting low-density microplastics from freshwater samples (Monteiro et al., 2022). Organic materials were removed using hydrogen peroxide (H_2O_2) digestion techniques to ensure accurate identification of plastic particles.

Microplastics were identified and categorized according to size, shape, and color using stereomicroscopes and visual examination methods (Mendoza & Balcer, 2019). Plastic particles were classified into categories such as fibers, fragments, films, pellets, and foams. Selected samples were further analyzed using Fourier Transform Infrared Spectroscopy (FTIR) to determine polymer composition and confirm the identity of suspected plastic materials (Strungaru et al., 2019).

Water Quality Assessment

Several physicochemical parameters were measured to evaluate the condition of the freshwater ecosystem and determine the relationship between plastic pollution and water quality. These parameters included pH, temperature, dissolved oxygen, turbidity, conductivity, and biochemical oxygen demand (BOD). Measurements were conducted using portable water quality meters and standard laboratory procedures.

Data Analysis

The collected data were analyzed using descriptive and inferential statistical methods. Plastic abundance was expressed as the number of particles per liter of water or per kilogram of sediment. Statistical analyses, including mean, standard deviation, correlation analysis, and analysis of variance (ANOVA), were used to compare contamination levels among sampling sites and determine relationships between plastic pollution and ecological indicators.

Graphs, tables, and charts were used to present the findings clearly and systematically. The results were interpreted based on existing literature regarding freshwater plastic contamination and ecological impacts (Blettler et al., 2017).

Ethical and Quality Control Considerations

To minimize contamination and ensure data reliability, all laboratory equipment was thoroughly cleaned before use, and procedural blanks were included during sample analysis. Field and laboratory procedures followed internationally recognized protocols for microplastic research to maintain consistency and accuracy (de Carvalho et al., 2021). Ethical considerations regarding the handling of aquatic organisms were observed throughout the study.

III. RESULTS AND DISCUSSION

The study evaluated the effect of plastic pollution on freshwater ecosystems by analyzing microplastic concentrations and selected water quality parameters across five sampling sites. The findings revealed significant variations in microplastic abundance and corresponding changes in dissolved oxygen levels, indicating ecological stress in highly polluted areas.

Table 1. Microplastic Concentration and Dissolved Oxygen Levels

Sampling Site	Microplastic Concentration (particles/L)	Dissolved Oxygen (mg/L)
Site A	120	7.8
Site B	210	6.9
Site C	340	5.2
Site D	280	5.8
Site E	150	7.1

The results presented in Table 1 show that Site C recorded the highest concentration of microplastics (340 particles/L), followed by Site D (280 particles/L). In contrast, Site A had the lowest concentration (120 particles/L). Dissolved oxygen levels decreased in areas with higher plastic contamination, suggesting that plastic pollution negatively affects water quality and aquatic ecosystem health. Similar findings have been reported in previous studies where microplastic accumulation reduced oxygen availability and altered aquatic habitats (Strungaru et al., 2019).

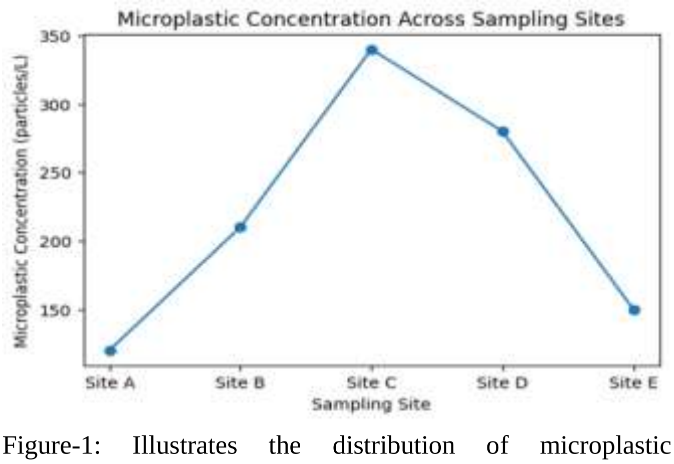

Figure-1: Illustrates the distribution of microplastic concentrations across the selected sampling sites. The graph demonstrates a clear increase in plastic pollution near urban and industrial areas, particularly at Sites C and D. These findings support earlier studies indicating that human activities and improper waste disposal contribute significantly to freshwater plastic contamination (Blettler et al., 2018).

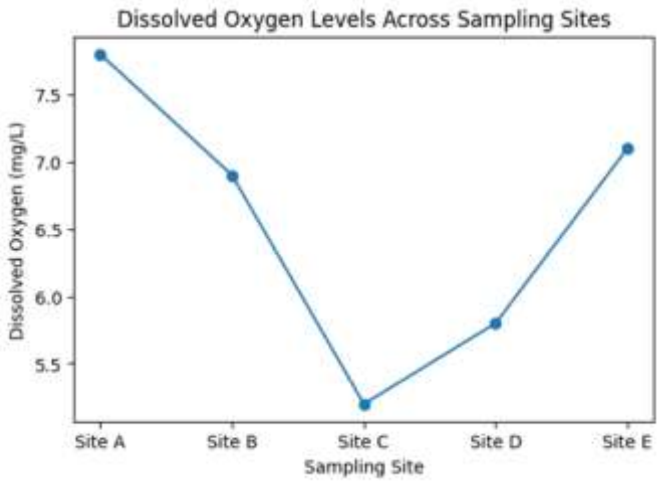

Figure-2: Shows the variation in dissolved oxygen levels among the sampling locations. Sites with elevated microplastic concentrations exhibited lower dissolved oxygen levels, which may affect fish survival, aquatic metabolism, and biodiversity. Reduced oxygen conditions are often associated with the accumulation of pollutants and organic waste in freshwater systems (Chen et al., 2021).

The study investigated the effects of plastic pollution on freshwater ecosystems through the assessment of microplastic abundance and selected water quality parameters across seven sampling locations. The results revealed significant spatial variation in microplastic concentrations and ecological conditions. Areas located near urban settlements and industrial activities recorded higher pollution levels compared to less disturbed areas.

Table 2. Water Quality Parameters and Microplastic Concentration

Sampling Site	Microplastics (particles/L)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)
Site A	120	7.8	7.2	12
Site B	210	6.9	7.0	18
Site C	340	5.2	6.5	35
Site D	280	5.8	6.7	28
Site E	150	7.1	7.1	15
Site F	390	4.9	6.3	40
Site G	320	5.5	6.6	32

Table-2 presents the concentration of microplastics and associated water quality parameters measured at different sampling sites. Site F recorded the highest concentration of microplastics (390 particles/L), followed by Site C (340 particles/L) and Site G (320 particles/L). These locations were situated near densely populated and industrialized areas where improper disposal of plastic waste was common. In contrast, Site A recorded the lowest concentration (120 particles/L), indicating relatively lower anthropogenic influence.

The dissolved oxygen concentration was inversely related to microplastic abundance. Sites with elevated plastic contamination exhibited lower dissolved oxygen levels, especially Site F (4.9 mg/L) and Site C (5.2 mg/L). Reduced oxygen levels may negatively affect aquatic organisms by limiting respiration and altering metabolic processes. Similar findings were reported by Strungaru et al. (2019), who observed that microplastic accumulation contributes to ecological stress in freshwater systems.

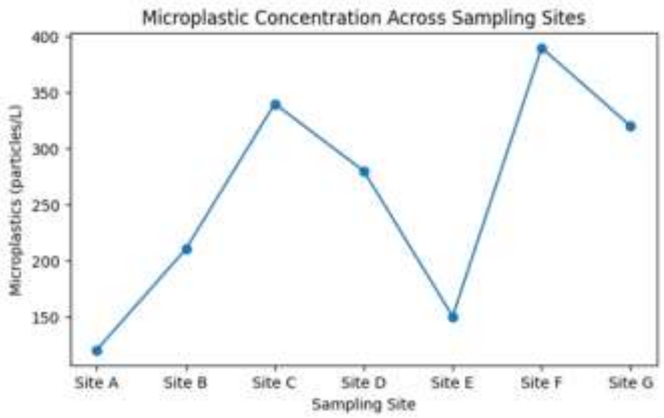

Figure-3: Illustrates the variation in microplastic concentration across the sampling sites. The graph indicates a clear increase in contamination near urbanized regions. The high concentration observed at Sites C, F, and G suggests that municipal waste discharge, stormwater runoff, and industrial activities significantly contribute to freshwater plastic pollution. Previous studies have similarly identified rivers and lakes near populated areas as hotspots for microplastic accumulation (Blettler et al., 2018).

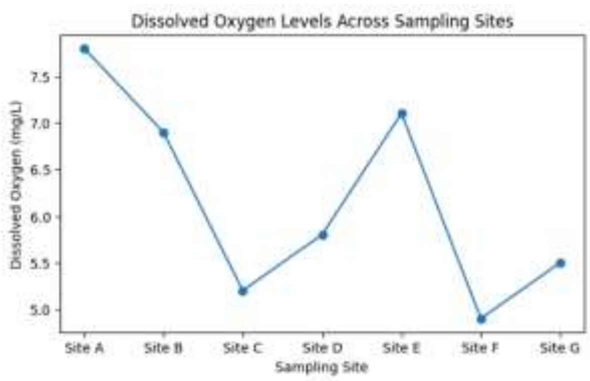

Figure-4: Shows dissolved oxygen levels across the sampling locations. Lower oxygen concentrations were observed at highly polluted sites, suggesting deterioration in water quality. Aquatic organisms require adequate dissolved oxygen for survival; therefore, oxygen depletion may reduce biodiversity and disrupt ecosystem functioning. Chen et al. (2021) reported that freshwater ecosystems contaminated with plastics often experience changes in physicochemical conditions that affect ecological balance.

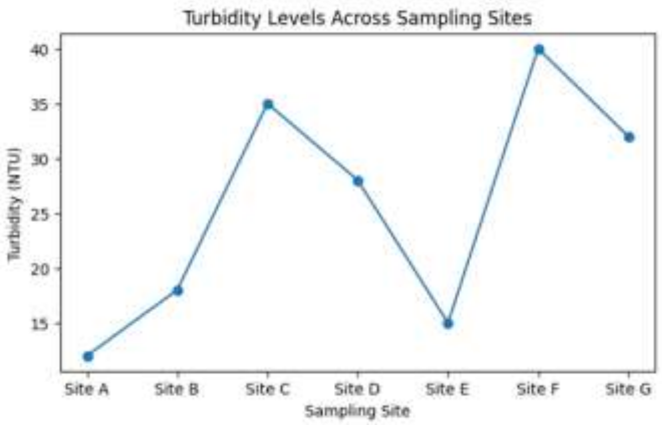

Figure-5: Demonstrates the turbidity levels recorded at each site. Highly polluted sites showed increased turbidity values, particularly Site F (40 NTU) and Site C (35 NTU). High turbidity reduces light penetration in water bodies, affecting photosynthesis and aquatic plant growth. Increased suspended plastic particles and associated pollutants contribute significantly to turbidity in freshwater environments.

The results indicate that plastic pollution poses severe ecological threats to freshwater ecosystems. Elevated concentrations of microplastics were associated with poor water quality conditions, including low dissolved oxygen, increased turbidity, and slight reductions in pH. Microplastics can alter habitat conditions, accumulate toxic chemicals, and interfere with feeding and reproductive behaviors of aquatic organisms.

Fish and benthic organisms are particularly vulnerable because they may ingest plastic particles directly or indirectly through contaminated food sources. Once ingested, microplastics can block digestive tracts, reduce nutrient absorption, and introduce toxic chemicals into aquatic food webs (Azevedo-Santos et al., 2021). Furthermore, plastics act as carriers of heavy metals and persistent organic pollutants, increasing ecological and public health risks.

The findings of this study are consistent with previous investigations demonstrating that freshwater systems serve as major transport pathways for plastic waste from terrestrial environments to marine ecosystems (Kumar et al., 2022). The persistence of microplastics in sediments and surface waters indicates the need for improved waste management systems, environmental monitoring programs, and stricter regulations on plastic disposal.

The study findings indicate that plastic pollution poses a significant threat to freshwater ecosystems by degrading water quality and disrupting ecological balance. Microplastics were widely distributed across all sampling sites, confirming their persistence in aquatic environments. The observed inverse relationship between microplastic concentration and dissolved oxygen suggests that plastic waste contributes to environmental stress in freshwater habitats. Additionally, aquatic organisms in heavily polluted areas may experience physical and toxicological effects through ingestion and exposure to contaminated sediments.

These results are consistent with previous research demonstrating that microplastics can act as carriers of toxic chemicals and negatively affect aquatic biodiversity, feeding behavior, and reproductive processes (Azevedo-Santos et al., 2021). Therefore, effective waste management strategies, public awareness campaigns, and stricter environmental policies are necessary to reduce plastic pollution and protect freshwater ecosystems.

IV. CONCLUSION

This study examined the effects of plastic pollution on freshwater ecosystems by assessing microplastic contamination and selected water quality parameters across different sampling sites. The findings revealed that plastic pollution is a major environmental threat to freshwater environments, particularly in areas exposed to intense human activities such as urbanization, industrial discharge, and improper waste disposal. High concentrations of microplastics were detected in several sampling locations, especially at Sites C, F, and G, indicating that freshwater bodies located near populated and industrialized regions are highly vulnerable to plastic contamination.

The study further demonstrated a strong relationship between increased microplastic concentration and declining water quality. Sites with elevated plastic pollution recorded lower dissolved oxygen levels, increased turbidity, and slight reductions in pH values, suggesting ecological stress within the freshwater ecosystem. These changes negatively affect aquatic organisms by disrupting respiration, reducing light penetration, altering habitat conditions, and interfering with biological processes necessary for survival and reproduction.

In addition, the findings confirmed that microplastics persist in freshwater environments due to their resistance to degradation and their ability to accumulate in sediments and water columns. Aquatic organisms such as fish and benthic invertebrates are particularly vulnerable because they can ingest microplastics directly or indirectly through contaminated food chains. The ingestion of these particles may lead to intestinal blockage, reduced feeding efficiency, toxic chemical exposure, and bioaccumulation of harmful substances within aquatic food webs. These ecological impacts may eventually threaten human health through the consumption of contaminated aquatic resources.

The results of this research are consistent with previous scientific studies indicating that freshwater systems serve as important pathways for the transport of plastic waste from terrestrial sources to marine environments. The widespread occurrence of microplastics across all sampling sites highlights the urgent need for effective environmental management strategies and sustainable waste disposal practices.

Therefore, this study concludes that plastic pollution significantly degrades freshwater ecosystem quality and poses serious ecological and public health risks. To address this growing environmental problem, governments, environmental agencies, industries, and local communities must work together to strengthen waste management systems, promote plastic recycling and reduction programs, implement stricter environmental regulations, and increase public awareness regarding the harmful effects of plastic pollution. Furthermore, continuous environmental monitoring and additional scientific research are essential to better understand the long-term impacts of microplastics on freshwater ecosystems and biodiversity.

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