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Microplastics in Water, Sediments and Benthic Macro invertebrates of an Urban Wetland (Case study: Sustan Wetland, Lahijan)

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Abstract

Microplastics are an emerging pollutant for all ecosystems and organisms that have caused great concern from different perspectives. Urban wetlands are an important aquatic ecosystem with unique characteristics and numerous organisms that are severely threatened by microplastics. Sostan Wetland, Lahijan is a special urban wetland with multiple input sources and various organisms. The aim of this study was to determine the amounts of microplastics in its water, sediments and benthic macro invertebrates. Six stations were selected and in summer 2025, sampling was carried out in them using standard methods and microplastics were separated, counted were examined in the laboratory. The results showed that the average number of microplastics in sediments was 273 pcs/kg, in water 146 pcs/L and in large benthic invertebrates 42% contaminated. Considering the amounts of microplastics in water, sediments and benthos of the wetland, it was determined that multiple sources of microplastic pollution have created the environment and food chain of these ecosystems and require specific management to improve the situation.

Key words: Microplastics, Urban Wetland, Benthos, Polymer, Pollution

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Introduction

Freshwater ecosystems worldwide are being damaged by human activities such as agricultural and domestic wastewater discharges (Maneechan & Prommi 2023) and are being exposed to a variety of pollutants such as toxins, heavy metals and plastics (Akpor et al., 2014). One emerging pollutant in water resources is the increasing amount of plastics, which is a significant concern for aquatic ecosystems worldwide (Lam et al., 2022). Microplastics, usually defined as plastic particles less than 5 mm in size, have been recorded in freshwater and marine environments (Barnes et al., 2009), along coastlines (Browne et al., 2011), in sediments (Claessens et al., 2013) and in the water column (Eriksen et al., 2013). The sources of microplastics vary, but most are derived from the breakdown of larger plastic items such as food and beverage containers, synthetic clothing fibers, industrial waste, and components of some cosmetic products (Biginagwa et al., 2016). This issue has received increasing attention in the scientific literature and the public media in recent years (Pallone, 2015), and much information has been published on how microplastics affect aquatic ecosystems and their organisms (Seltenrich, 2015), and studies of the effects of microplastics on aquatic food webs have increased exponentially (Lusher et al., 2017). The concentration and bioavailability of microplastics in water sources are influenced by factors such as upstream land use, urban runoff, and the relative volume of wastewater discharged from sewage treatment plants (Besseling et al., 2017; Nel et al., 2018) and are often used in common forms such as polyvinyl chloride (PVC), polystyrene (PS), polyethylene (PE), polyester (PES), and polypropylene (PP) (Dube and Okuthe, 2023; Desidery and Lanotte 2022) and their fate in aquatic environments depends on their density and polymer composition, and these properties affect their buoyancy and position in the water column (Khan et al., 2022). These physical factors that influence the presence and abundance of microplastics in the environment determine the likelihood of their ingestion by aquatic organisms, particularly those whose feeding habits involve ingesting organic particles or filtering material from the water column (Wright et al., 2013).

Laboratory and field assessments indicate that ingestion and transport of microplastic particles (MPs) can affect aquatic organisms (Wright et al., 2013), including zooplankton (Cole et al., 2015), invertebrates (von Moos et al., 2012), fish (Lusher et al., 2013), and birds (Provencher et al., 2022). Studies investigating plastic contaminants in freshwater environments have focused mostly on higher trophic level organisms such as fish (Foekema et al., 2013; Sanchez et al., 2014), but recent studies have identified ingestion of microplastics by freshwater invertebrates, including the tubificid worms Gammarus pulex and Hyalella azteca (Hurley et al., 2017; Weber et al., 2018;). Wetlands are highly complex and productive ecosystems that, due to their immobile nature and multiple inputs, can have the potential for contaminants to enter. One key characteristic of wetlands is their capacity to act as sinks for some nutrients and to remove pollutants from agricultural runoff (Tournebize et al., 2017). Wetlands are unique ecosystems formed by the interaction of aquatic and terrestrial ecosystems, which have important functions in maintaining biodiversity and degrading pollutants (Longo et al., 2022). The vegetation of wetlands is an effective retaining media of MPs, and these ecosystems might be an important reservoir of plastic particles (Lei et al., 2018). Wetland sediments can act as a sink for MP particles and a hotspot for MP pollution (Abidli et al., 2019). However, the abundance and distribution of MPs in wetland systems (include lagoons) are poorly studied, in comparison to other aquatic systems (Helcoski et al., 2020). Given the geographical, ecological characteristics, and numerous pollutant sources in this wetland, the goal of this research is to investigate the presence, abundance, and characteristics of microplastics in sediments, water, and benthos, and the hypothesis of this study will be the presence of microplastics in all three parts.

Materials and Methods

In order to conduct this research, six sampling stations were selected in the Sustan Wetland according to the characteristics of each location, ecological conditions, and wastewater input sources, and water, surface sediments, and large benthic invertebrates were sampled in them in the summer of 2025.For surface water sampling, 20 liters of water were initially collected using a glass bottle and poured into a plankton net with a mesh of 0.35 mm and a diameter of 50 cm (Free et al., 2014). Then, the samples were stored in a volume of one liter in a glass bottle containing 2.5% formalin (Collignon et al., 2012). Sediments were also collected to a depth of 5 cm using a Van Veen 22 grab (25 cm2) in three replicates, 10 m apart, randomly and as one sample for each location. Wet sediment was placed in an aluminum foil bag and transported to the laboratory (Rasta et al., 2022; Löder and Gerdts 2015) and then sieved on a 5000 µm mesh size to remove particles larger than 5000 µm (Corcoran, 2015). To obtain benthic samples, considering the water depth and the substrate type, which was mainly mud-silt, a Grab Ekman device (with an area of 40 × 40 cm and a depth of 5 to 10 cm) was used. Sampling was carried out in 3 replicates at each station and was initially washed in a special benthic sieve and then placed in glass containers and water and 4% pure formalin were added (Ortiz & Puig, 2007).

Separation of microplastics from water, sediments and benthos

Filter funnels were used to remove organic matter from the samples. First, the samples were subjected to wet peroxide oxidation (WPO) in the presence of a bivalent iron catalyst at 75 °C, then hydrogen peroxide was added to the samples to completely remove organic matter (Free et al. 2014). For flotation and separation of microplastics, a saturated solution of table salt (1.2 g/cm3), previously prepared in a 1000 ml volumetric flask, was added to the samples (Eriksen et al. 2013;). The beaker was then shaken for five minutes to suspend the particles. After the suspension had settled for approximately 1 hour, the supernatant was passed through glass funnels onto 5-µm nitrocellulose filter paper (Hidalgo-Ruz and Thiel 2015). Finally, the filter paper containing the particles was dried in an oven at 40°C for 24 hours and examined microscopically (Law et al. 2010). This process was repeated three times for each station sample.

Quality Control

Laboratory equipment was cleaned with 70% ethanol before use to prevent airborne contamination. A cotton lab coat and nitrile gloves were worn during the analysis procedures. Solutions required during the experiment were filtered before use. All sample containers were covered with aluminum foil to prevent airborne contamination. Three controls containing distilled water were used as controls during the experimental analysis. The final results were corrected by subtracting the control contamination from the MPs counted in the samples (Brander et al, 2020). The separated microplastics on the filters were observed and counted under a stereo microscope M205A (Leica, Germany) with a magnification range of 40-100 times (Reddy et al., 2006).

Result

The results obtained from the studies conducted on the samples, separation and counting of microplastics from water, sediments and macrozoobenthos in the Sostan Lahijan wetland showed that amounts of microplastics are observed in all three environments. The results showed that the average number of microplastics in sediments was 273 pcs/kg, in water 146 pcs/L and in large benthic invertebrates 42% contaminated. As Figure 1 shows, the average number of microplastics in one liter of water in the Sostan Lahijan wetland was 146 per liter, with the highest number at station 6 and the lowest at station 3. There was no statistically significant difference between stations 1, 2, and 3, and the other three stations had statistical differences with and without these stations.

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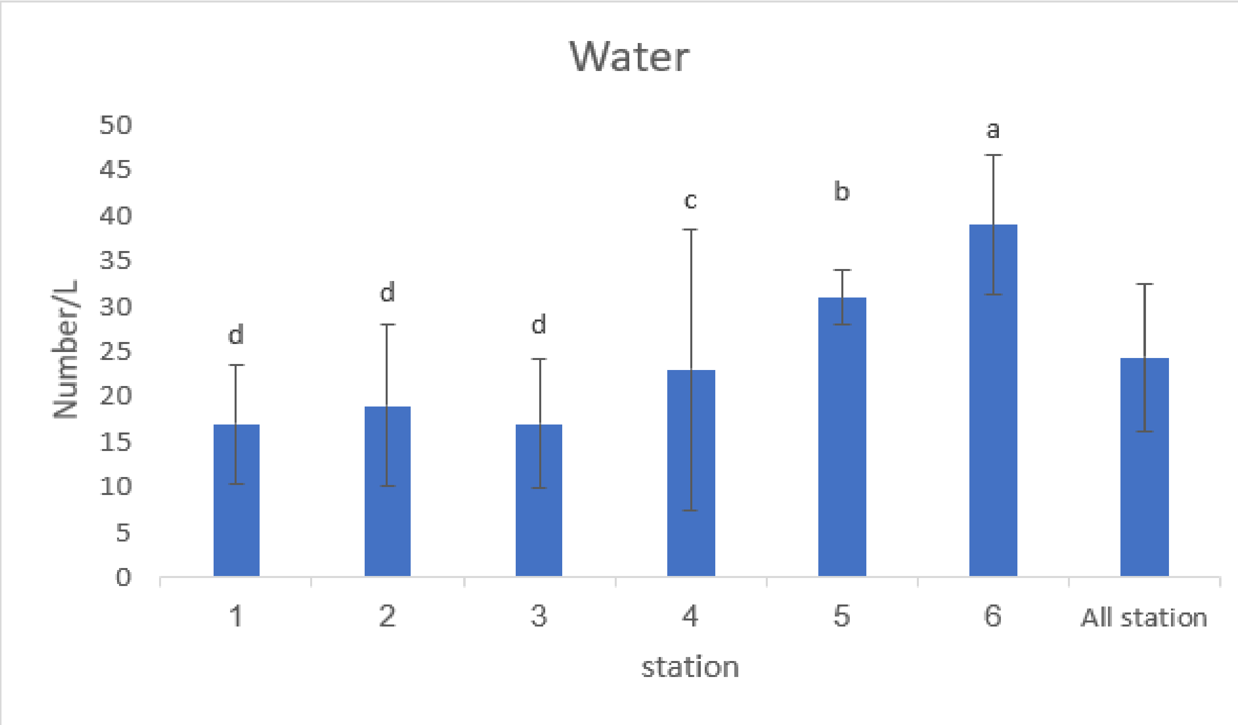

Fig. 1: The average number of microplastics in one liter of water from Sostan Wetland, Lahijan, and their mean and standard deviation.

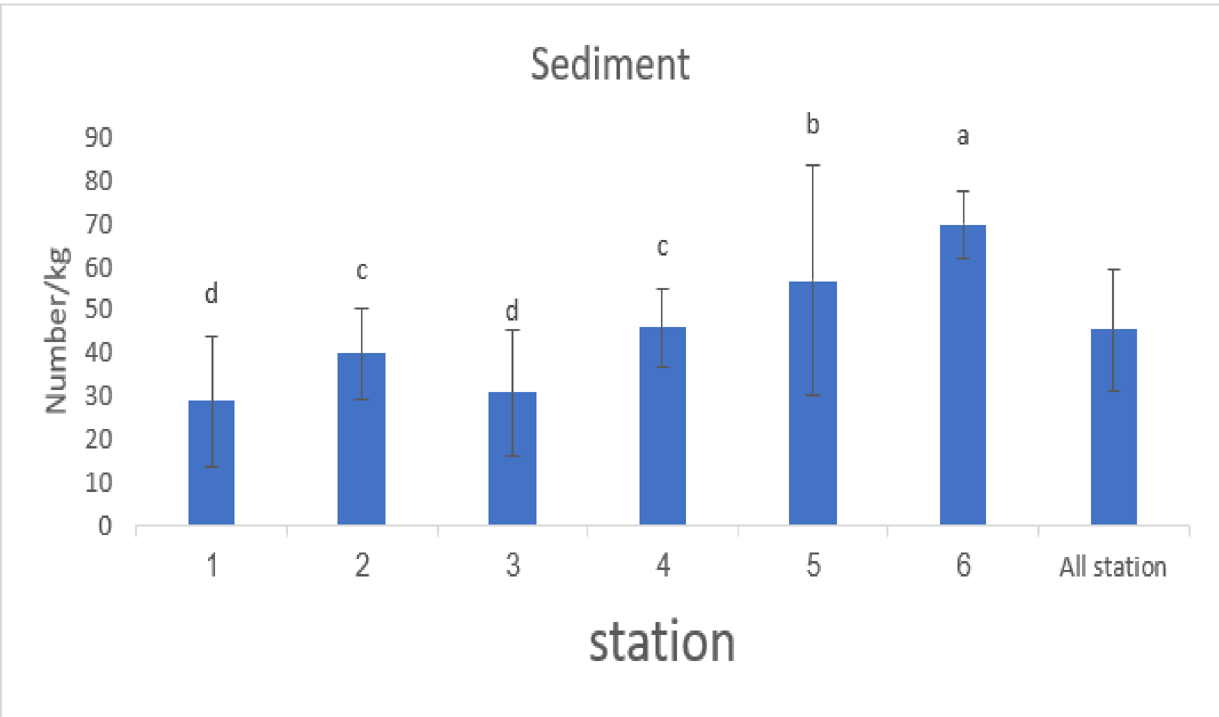

Fig. 2: Average number of microplastics per kilogram of sediments from Sostan Wetland, Lahijan, and their mean and standard deviation

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As Figure 2 shows, the average number of microplastics in one kg of sediment in the Sostan Lahijan wetland was 273 per kg, with the highest number at station 6 and the lowest at station 3. There was no statistically significant difference between stations 1, 2, and 3, and the other three stations had statistical differences with and without these stations. As Figure 3 shows, the average number of microplastics in the macroinvertebrates in the Sostan Lahijan wetland was 7, with the highest number at station 4 and the lowest at station 2. There was no statistically significant difference between stations 1, 2, and 3, and the other three stations had statistical differences with and without these stations. Figure 4 shows a general diagram of the abundance of microplastics in the three environments of water, sediments, and large benthic invertebrates in the Sostan Lahijan Wetland at 6 stations side by side, which shows that the highest abundance at all stations is in sediments, second in water, and lower in benthos than in the previous two environments.

Discussion

Although wetlands are key ecosystems for the transfer of urban microplastic pollution sources to freshwater environments, few studies have reported the characteristics of microplastics in urban wetlands. Recent studies have only focused on the occurrence of microplastics in wetlands. Therefore, this study investigated and analyzed the abundance of microplastics in the urban wetland of Sustan Lahijan (surface water, sediments, macroinvertebrates). The abundance of microplastics in surface water, sediments, and benthos was in the range of 15–40 items per liter, 25–75 items per kilogram, respectively. The main analyses showed that wastewater is the main source of microplastics in the urban part of this wetland, with agricultural waste also contributing. This first quantitative measurement of the removal of small microplastics (50–500 μm) across an urban wetland provides key reference information for controlling the environmental risk of microplastics in aquatic environments.

Urban wetlands are important pathways for microplastics to enter aquatic environments (Blair et al., 2019). Therefore, urban wetlands are pivotal environments for the transport of microplastics in the global ecosystem. In addition, agricultural activities also occur around most urban wetlands, which also cause microplastic pollution due to agricultural waste (Huang et al., 2020; Kim et al., 2021). Urban wetlands, often characterized by abundant vegetation, slow water flow, and humus-rich sediments, are ideal areas for the absorption, trapping, and storage of microplastics and also act as major potential barriers (Qian et al., 2021). However, although urban wetlands have great potential to reduce terrestrial microplastics (Sarkar et al., 2021).

Given that urban wetlands, especially Sustan Wetland, have multiple entrances, and urban and agricultural wastewater, along with tourist waste, enter it, and the bed is full of organic matter, as well as the presence of dense aquatic plants, all of which provide the conditions and potential for receiving and storing microplastics in Sustan Wetland. The results of this study also confirmed the presence of this pollutant in its water, sediments, and large benthic invertebrates. Therefore, special attention should be paid to the pollutants in this wetland.

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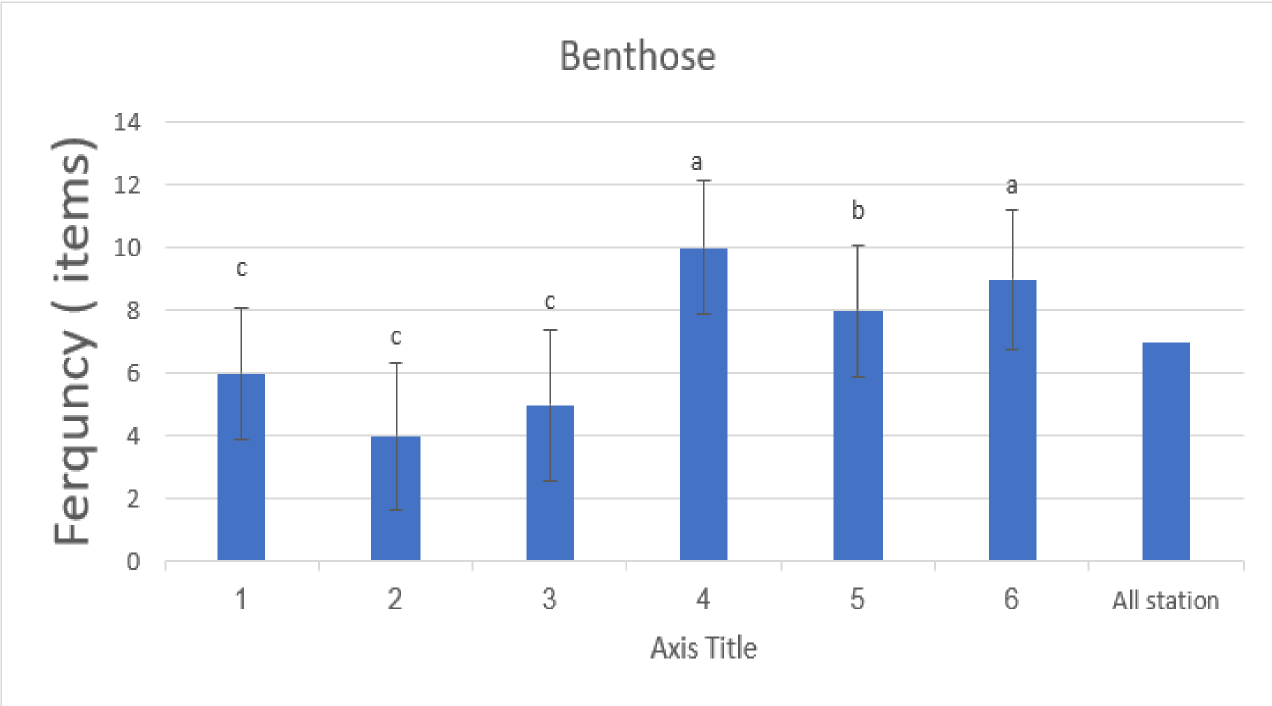

Figure 3: Average number of microplastics in the large benthic sediments of the Sostan Wetland, Lahijan, and their mean and standard deviation

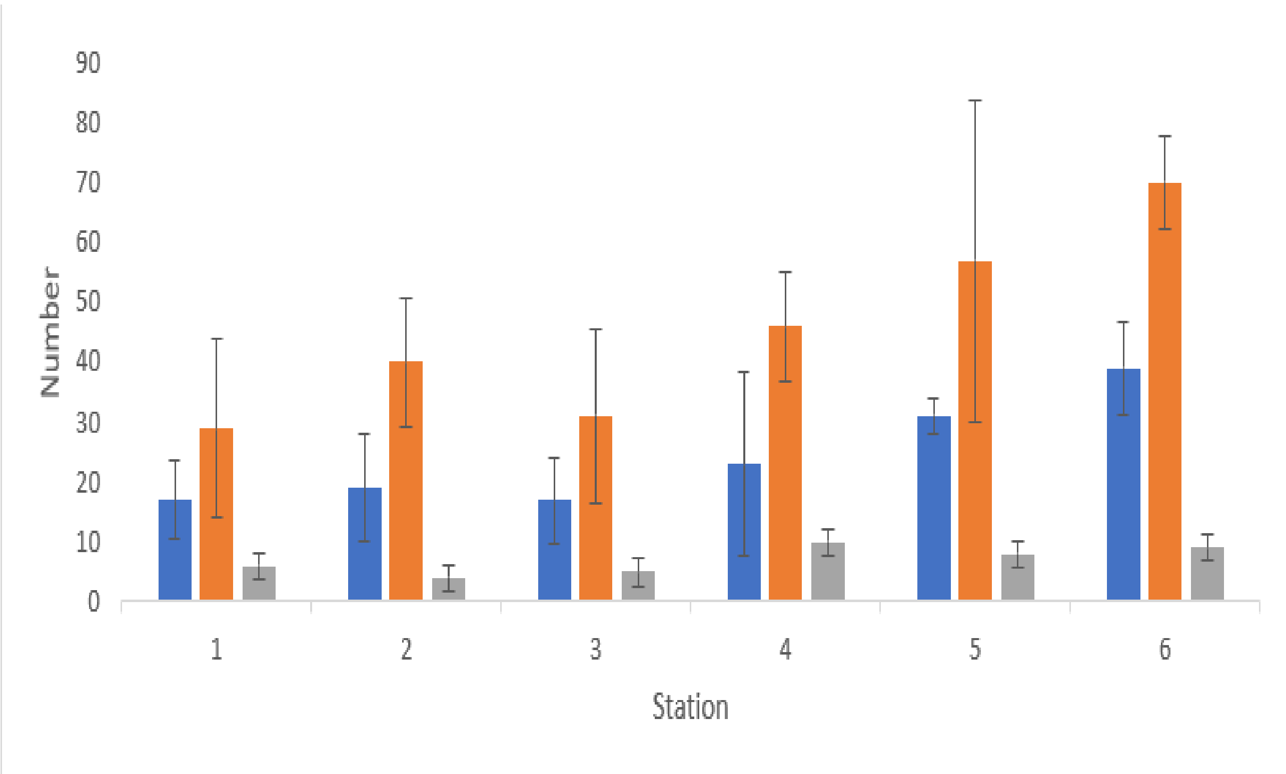

Fig. 4: Comparison of the average number of microplastics in one liter of water, one kilogram of sediments, and in Macrozoobenthos of the Sostan Lahijan Wetland and their standard deviations

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