Water Biology and Security 2 (2023) 100185

Contents lists available at ScienceDirect

Water Biology and Security

journal homepage: www.keaipublishing.com/en/journals/water-biology-and-security

Research Article

Seasonal occurrence of microplastics in sediment of two South African recreational reservoirs

Thendo Mutshekwa [a,*], Linton F. Munyai [b], Lutendo Mugwedi [a], Ross N. Cuthbert [c,d], Farai Dondofema [a], Tatenda Dalu [b,d,e]

[a] Aquatic Systems Research Group, Department of Geography and Environmental Sciences, University of Venda, Thohoyandou, 0950, South Africa
[b] School of Biology and Environmental Sciences, University of Mpumalanga, Nelspruit, 1200, South Africa
[c] Institute for Global Food Security, School of Biological Sciences, Queen's University Belfast, BT9 5DL, Belfast, Northern Ireland, UK
[d] South African Institute for Aquatic Biodiversity, Makhanda, 6140, South Africa
[e] Stellenbosch Institute for Advanced Study, Wallenberg Research Centre at Stellenbosch University, Stellenbosch, 7600, South Africa

ARTICLE INFO

Keywords:
Emerging pollutant
Plastic debris
Contamination
Microplastics
Freshwater pollution

ABSTRACT

Inland water systems are regarded as a pathway and sink of plastic pollutants from the terrestrial environment. Aquatic ecosystems are globally contaminated with microplastics, but the spatiotemporal occurrence and density of microplastics in freshwater ecosystems remain poorly understood. The present study seasonally assessed differences in microplastic density in the sediments from two South African recreational reservoirs associated with low human activities (macadamia orchards) and high human activities (communal areas). Microplastics were recovered from all of the reservoirs assessed, indicating their extensive occurrence and densities. Microplastic numbers were significantly higher in reservoirs associated with high anthropogenic activities during the hot-dry season (140.6 particles kg^{-1} dwt) and lower in reservoirs associated with low anthropogenic activities during the hot-wet and cool-dry seasons, i.e., 22.60 particles kg^{-1} dwt and 16.13 particles kg^{-1} dwt, respectively. Overall, polypropylene (31%) and polystyrene (30%) were identified as the dominant types of microplastic polymer in both reservoir types. Moreover, no correlative relationships were observed for environmental parameters and microplastic densities across reservoirs and seasons, suggesting a widespread and largely context-independent pollution level. These results show that microplastics are not evenly distributed between waters associated with low human activities and high human activities. Future work should seek greater sample sizes and centre around observing microplastic contamination in the region by examining their sources, transport, and impacts to freshwater environments, whilst informing management strategies.

1. Introduction

Microplastics are considered one of the main sources of freshwater ecosystem pollution (Wagner et al., 2014). Microplastics are regarded as any synthetic solid particle or polymeric matrix with a regular or irregular shape, sizes ranging from 1 μm to 5 mm, and that are insoluble in water (Frias and Nash, 2019). Microplastics can be classified as primary or secondary, depending on the manner in which they are produced. Primary microplastics are particles released directly into the environment via domestic and industrial effluents, spills and sewage discharge, or indirectly via run-off (Cesa et al., 2017). Secondary microplastics are formed as a result of gradual degradation/fragmentation of larger plastic particles already present in the environment, for example, through ultraviolet radiation (photo-oxidation), mechanical transformation (e.g., waves abrasion), and biological degradation by microorganisms (Cesa et al., 2017; Cao et al., 2022).

Microplastics have become one of the leading threats to aquatic environments due to their persistence, ubiquity, and intrinsic toxic potential (Zhao et al., 2014). Over the past decades, global production of plastics has increased drastically from 1.5 million to 322 million tonnes per year (Coppock et al., 2017). Worldwide, rivers are predicted to transport between 0.4 and 2.75 million tonnes of plastic from land to the oceans annually (Lebreton et al., 2017; van Emmerik et al., 2019). The majority of microplastic particles entering the freshwater ecosystem is primarily from secondary microplastics generated by the breakdown of larger plastic items, for example, single-use packaging, tyres, and fibres

* Corresponding author.
E-mail address: thendzamuchekwa@gmail.com (T. Mutshekwa).

https://doi.org/10.1016/j.watbs.2023.100185
Received 5 November 2022; Received in revised form 23 March 2023; Accepted 24 April 2023
Available online 15 May 2023

from synthetic fabric (Free et al., 2014; Zhao et al., 2014). These microplastics can enter freshwater through surface and agricultural runoffs or direct disposal of wastes as a result of poor waste management (Free et al., 2014). As a result of poor waste management, concerns related to the impacts of microplastics in freshwater environments have risen rapidly.

Although effects can be mixed among studies, microplastics can have adverse impacts on the environment (Anbumani and Kakkar, 2018; Völker et al., 2020; Acharya et al., 2021) and are one of the primary contributors to riverine plastic pollution by mass (Acharya et al., 2021). The potential toxicity of microplastics to aquatic life forms likely stems from one of three pathways: (i) ingestion of microplastics, (ii) concentration and transfer of organic pollutants, and (iii) leakage of additives from plastics (Wong et al., 2020). Microplastics are known to affect various life forms within the river system and can have adverse effects on livelihoods (for example, when plastic debris blocks culverts and increases flooding; Al-Zawaidah et al., 2021).

Assessing the detrimental effects of microplastics on inland freshwater environments is challenging because they include a variety of physical (e.g., size, shape, colours) and chemical (e.g., polymer, adhesives, other chemicals) compounds, which regulate their fate, transport, and bioaccumulation across ecosystems (Thompson et al., 2004; Andrady, 2011; Miller et al., 2021). Despite these challenges, microplastics have been noted to affect biological and physico-chemical processes of significance for organisms, communities, and ecosystems. For instance, aquatic organisms are known to be severely affected by the smaller size of microplastics because they can be easily consumed, disrupting their physiological functions (do Sul et al., 2014; Issac and Kandasubramanian, 2021). Regardless of microplastic size, plastic debris will ultimately sink to the water systems floor due to changes to its physical properties (e.g., density, size, shape, and hetero-aggregation with other particulates) over time and through biological effects (e.g., marine snow, faecal repackaging, and biofouling) (Harris, 2020). Sediments are thus considered as an important sink for microplastics. The fate and transport of microplastics is considered to be a function of their physicochemical properties, hydrodynamic factors, and the characteristics of surface sediments (Harris, 2020; Mintenig et al., 2020).

The existence of microplastic in aquatic environments has been well known to be influenced by anthropogenic activities such as manufacturing industries, personal care products, and wastewater discharge (Horton and Barnes, 2020; Elgarahy et al., 2021). However, some studies (e.g., Wang et al., 2021; Haixin et al., 2022) have found the influence of anthropogenetic activities on the distribution and occurrence of microplastics in the environment to be inconsistent with differences in the microplastic densities and characteristics. Therefore, further research is needed to clarify this relationship. In addition to anthropogenic activities, seasonal changes can influence the distribution of microplastics and densities.

Investigations of the temporal or seasonal variations of microplastic occurrence in inland aquatic freshwater ecosystems are relatively scarce. Several studies have demonstrated seasonal variations in the occurrence of microplastics in river systems, which are closely related to surface runoff flows, temperature, and discharge loads (Ouyang et al., 2020; Xia et al., 2021; Dalu et al., 2021). Studies (e.g., Xia et al., 2020; Honingh et al., 2020) have also indicated that plastic debris enters water systems through surface runoff during the rainy season. Due to the ability of rainy seasons to increase the accumulation of smaller microplastics into aquatic environments, dry seasons are known to be associated with a higher density of microplastics in sediments through deposition and reduced river flow (Xia et al., 2021).

In South Africa, microplastic studies in marine environments are limited but are actively being pursued (Vester et al., 2017). However, with South Africa being a water-scarce country, concerns about microplastic dynamics, impacts on the quality of aquatic resources, and ecotoxicological effects on aquatic biota and humans, have also shifted towards inland waters (Mendoza and Balcer, 2019; Bulannga and Schmidt, 2022). Despite the numerous investigations on microplastic pollution in sediments from freshwater ecosystems in South Africa (e.g., Nel and Froneman, 2015; 2018; Mbedzi et al., 2020), studies focusing on the status of microplastic pollution associated with human activities are scarce. To evaluate the environmental risk of microplastics comprehensively, it is essential to characterise their occurrence and density. The present study was therefore aimed to assess microplastic densities in sediments from recreational tropical reservoirs with either high human activities (communal area) or low human activities (macadamia orchards) across seasons. We hypothesized that sediments in the communal area reservoirs would have increased microplastic densities compared to those in macadamia orchards. We further hypothesized that microplastic densities would demonstrate a strong seasonal variation (hot–dry, hot–wet, cool–dry) with hot–dry driving increased particle numbers.

2. Materials and methods

2.1. Study area

We selected four reservoirs for surveying microplastics, two macadamia orchards and two communal areas. The two macadamia orchard reservoirs (reservoir 1, 23°06′31.6″S, 30°15′54.2″E; reservoir 2, 23°06′54.5″S, 30°15′46.5″E – hereafter referred to as L1 – L2) are located in the southern foothills of the Soutpansberg range, 20 km east of the town of Makhado (previously Louis Trichardt) (Fig. 1). Both locations are approximately 10 km from the town of Thohoyandou, Limpopo province, South Africa, and these reservoirs are mainly used for domestic water supply and irrigation. The two reservoirs are located in a nut-growing area, which is dominated by extensive monocultures of macadamia plantations with low human population density (i.e., 207). The annual rainfall range of the area is 540–544 mm, with the highest precipitation occurring between November and April. Daily maximum temperatures frequently exceed 35 °C in summer (October to March) and the average annual temperature is 26 °C. Macadamia orchard reservoirs are impounded streams and have estimated surface areas of 824 and 950 m^2 and depths of 6 and 8 m, respectively.

The two communal area reservoirs (reservoir 3, 22°56′43.0″S, 30°23′01.9″E; reservoir 4, 22°58′03.72″S, 30°23′51.71″E – hereafter referred to as H3 – H4) are located in Duthuni reservoir within Thulamela Municipality (Fig. 1). The communal area (i.e., Duthuni – human population density 6600) has a humid, subtropical climate and receives an average annual rainfall range of between 400 and 800 mm. High temperatures (i.e., up to 40 °C) occur between October and March, with the cool–dry season temperatures ranging between 12 °C and 22 °C. Communal area reservoirs were surrounded by residential areas with high human activities along their shorelines, such as irrigated crop and orchard farming, fishing, and other residential domestic activities (i.e., laundry, swimming, picnics, bathing). Communal area reservoirs are impounded streams and have estimated surface areas of 140.2 and 111.3 m^2 and depths of 5 and 6 m, respectively. The study was carried out over three seasons, i.e., hot–dry (November 2021), hot–wet (March 2022) and cool–dry (June 2022).

2.2. Environmental parameters

Water parameters (i.e., temperature (°C), pH, conductivity ($\mu S \cdot cm^{-1}$), total dissolved solids and ($mg \cdot L^{-1}$)) were measured using a multi-parameter handheld waterproof Cyber Scan 300 (EuTech Instruments, Singapore) from 3 sites per each reservoir across the 3 different seasons.

2.3. Microplastic extraction

To prevent contamination, prior to all analyses, the entire laboratory was cleaned with all surfaces and equipment rinsed with Milli-Q distilled water with all laboratory windows closed. No air-conditioners or fans were utilised in the lab during the study to minimise the risk of potential

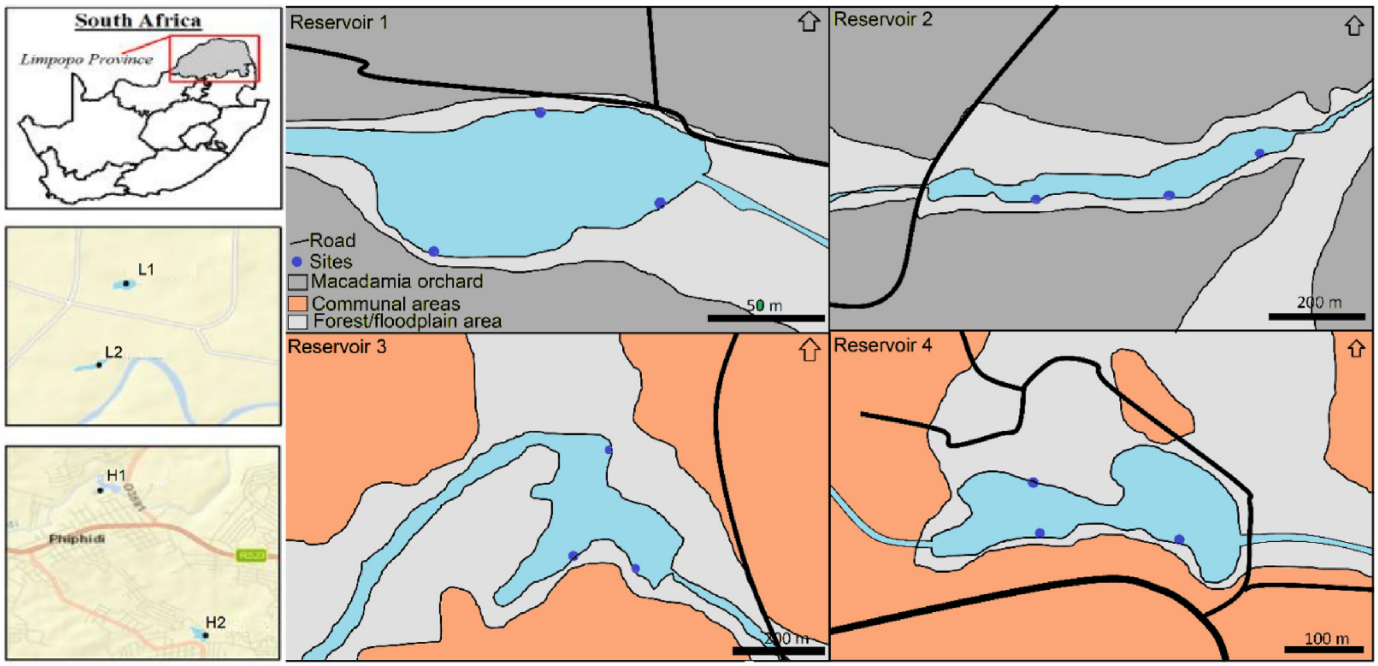

Fig. 1. Location of the sample collection reservoirs (reservoirs 1 and 2 – macadamia orchards; reservoirs 3 and 4 – communal area) in Limpopo province of South Africa.

air-borne microplastic particle transport. Sediment samples (~2–2.5 kg, depth ~5–10 cm) at each site (n = 3) per reservoir and season were collected using a steel hand shovel after the removal of the overlaying debris. Upon collection, the samples were placed into new labelled Ziplock bags and immediately packed in a cooler bag with ice and transported to the University of Venda laboratory for further analysis, following a procedure by GESAMP (2019) and Dalu et al. (2021). Upon arrival in the laboratory, sediment samples were dried in an oven at 50 °C for a minimum of 3 days, until a constant weight was reached. Four 500 g subsamples (i.e., 4 × 500 g subsample per site) were separated using a riffle splitter and sieved through a 500 μm mesh steel sieve to remove large organic matter particles and rocks. The remaining sediment was weighed, allowing the concentration of microplastic particles kg^{-1} of dry weight (dwt) to be determined. Material retained on the sieve was analysed for large microplastics (2–5 mm), for inclusion in the total microplastics count. Each sieved subsample was then placed in a pre-rinsed 5 L glass beaker and a 63 μm mesh filtered hyper-saturated saline solution (100 g L^{-1}) was added, following the procedure by Mbedzi et al. (2020). The mixture was stirred vigorously, allowing the less dense microplastic particles to float to the surface (Lusher et al., 2015). The supernatant of individual subsamples was filtered through a 63 μm mesh. This density separation process was repeated five consecutive times, in order to maximise the recovery of microplastics. The remaining particles on the mesh were carefully rinsed with distilled water into 50 mL glass containers. The samples were then visually sorted under an Olympus dissecting microscope at × 50 magnifications, whereby all possible microplastic particles were enumerated. Microplastic particles were identified by possessing unnatural colouration (e.g., pink/red, white, black/blue, yellow/orange, green) (Hidalgo-Ruz et al., 2012). Furthermore, to ensure that sediment samples were not contaminated during the extraction process, control containers (i.e., without sediment samples) were also included during the experiment.

As visual inspection alone was not adequate to characterise and exhaustively quantify microplastics, a further physical analysis was utilised (Mintenig et al., 2017). The plastic particles with sizes between 2 and 5 mm were selected for polymer identification using a vibrational Platinum-ATR Fourier-transform infrared spectroscopy (FT-IR) (Bruker Alpha model, Germany) technique with a spectral region of 650–4000 cm^{-1}, resolution of 8 cm^{-1}, and a rate of 16 scans per analysis. This technique offers available libraries for microplastic polymer identification and is more efficient for dense samples, as in the present study (Picó et al., 2019). All spectra were compared, and identification was verified using the following databases (Hummel Polymer Sample Library, HR Polymer Additives and Plasticizers, HR Hummel Polymers and Additives, Synthetic Fibres by Microscope).

2.4. Statistical analyses

A two-way analysis of variance (ANOVA) was used to assess any differences in environmental parameters and sediment microplastic densities/colours among reservoirs and seasons after testing for homogeneity of variances (Levene's test, $p > 0.05$) and normality of distribution (Shapiro-Wilk test, $p > 0.05$). We used reservoirs and seasons as explanatory variables and environmental parameters and microplastic densities and colours (i.e., red/pink, white, black/blue, yellow/orange and green) as response variables. For these models, *post-hoc* Tukey multiple comparisons were performed where effects were significant. Pearson correlations were also carried out to assess the relationships between environmental parameters (i.e., temperature, pH, conductivity, total dissolved solids) and microplastic particle numbers. In all analyses, significance was inferred at $p < 0.05$ and all statistical analyses were performed using IBM SPSS version 25.

3. Results

3.1. Environmental parameters

Differences in environmental parameters over the sampling reservoirs are highlighted in Table 1. Across reservoirs and seasons, temperature (range: 25.3–28.7 °C), pH (range: 6.4–7.5), conductivity (range: 276.4–422.2 μS cm^{-1}), and total dissolved solids (range: 127.1–233.9 mg L^{-1}) differed substantially (Table 1). Significant reservoir differences were observed for conductivity (ANOVA, $F = 8.060$, $p < 0.001$) and TDS (ANOVA, $F = 10.375$, $p < 0.001$), whilst seasonal differences were observed for pH (ANOVA, $F = 4.463$, $p = 0.02$) and TDS (ANOVA, $F = 7.729$, $p = 0.003$), and reservoirs × season interactions were observed for

Table 1
Mean ± SD description of environmental parameters measured across sampled reservoirs: macadamia orchards, L – low human activities, and communal area, H – high human activities.

Variables	Unit	Reservoirs	Hot–dry	Hot–wet	Cool–dry
Temperature	°C	Macadamia	25.9 ± 1.7	27.7 ± 0.4	28.7 ± 0.8
		Communal	25.3 ± 0.8	26.9 ± 1.4	26.5 ± 0.6
pH		Macadamia	6.4 ± 0.3	7.5 ± 0.3	7.3 ± 0.3
		Communal	7.1 ± 0.2	7.4 ± 0.2	7.0 ± 0.5
Conductivity	$\mu S \cdot cm^{-1}$	Macadamia	276.4 ± 38.3	393.8 ± 72.1	286.7 ± 23.6
		Communal	341.5 ± 21.6	305.7 ± 12.7	422.2 ± 57.4
Total dissolved solids	$mg \cdot L^{-1}$	Macadamia	127.1 ± 16.1	211.2 ± 28.7	143.3 ± 10.8
		Communal	170.0 ± 10.6	157.5 ± 10.0	233.9 ± 24.1

conductivity (ANOVA: F = 5.506, $p = 0.001$) and TDS (ANOVA: F = 8.229, $p < 0.001$). Pairwise multiple comparisons found significant differences between L1 and L2 ($p < 0.001$) and L2 and H3 ($p = 0.002$) for conductivity, L1 and L2 ($p < 0.001$), L2 and H3 ($p < 0.001$), and L2 and H4 ($p < 0.001$) for TDS, whilst for seasons differences were found between hot–dry and hot–wet ($p < 0.001$) for pH, and hot–dry and hot–wet ($p < 0.001$) and hot–dry and cool–dry ($p < 0.001$) for TDS.

3.2. Microplastic densities

Control samples contained no microplastics. As such, microplastics encountered in samples were considered to be from the collection reservoirs and not an outcome of laboratory contamination. Overall, across reservoirs, mean microplastic densities ranged from 25.3 particles kg^{-1} dwt to 140.6 particles kg^{-1} dwt. Generally, high microplastic densities were recovered in high human activities reservoirs, reservoir 3 (140.6 ± 28.4 particles kg^{-1} dwt) and reservoir 4 (129.7 ± 10.8 particles kg^{-1} dwt), whereas low microplastic densities were recovered in low human activities reservoirs, reservoir 1 (17.8 ± 4.6 particles kg^{-1} dwt) and reservoir 2 (16.1 ± 3.3 particles kg^{-1} dwt). Overall, across sites categorised as low human and high human activities, significant differences were observed (ANOVA, F = 2.628, $p = 0.01$).

With regard to seasons, overall, across sites, hot–dry seasons were associated with increased microplastic densities (mean range 33.1–140.6 particles kg^{-1} dwt) compared to that of hot–wet (mean range 22.6–97.8 particles kg^{-1} dwt) and cool–dry (mean range 16.1–74.4 particles kg^{-1} dwt) (Fig. 2), albeit, reservoir-specific variability was high. Significant differences were observed for microplastic densities across reservoirs (ANOVA, F = 22.151, $p < 0.001$), seasons (ANOVA, F = 9.532, $p < 0.001$), and reservoirs × seasons (ANOVA, F = 3.005, $p = 0.02$). The significant reservoir × season interaction indicated that the communal area (high human activities) responded most strongly to hot–dry seasons. Pairwise multiple comparisons highlighted significance differences in densities for L1 vs H3 ($p < 0.001$), L1 vs H4 ($p < 0.001$), L2 vs H3 ($p < 0.001$), and L2 vs H4 ($p < 0.001$). Moreover, pairwise comparisons indicated significant differences across reservoirs and seasons for hot-dry vs cool-dry ($p = 0.01$).

Microplastics were found in a variety of colours (i.e., red/pink, white, black/blue, yellow/orange and green) (Fig. 3). White particles made up the majority of microplastic densities across seasons and reservoirs, accounting for 72.3% of the total microplastic particles, followed by black/blue (15.0%), pink/red (5.2%), yellow/orange (4.9%), and green (2.3%). Significant differences were observed for all microplastics colours across reservoirs (all: ANOVA, $p < 0.05$), whereas across seasons, significant differences were observed for white (ANOVA, F = 3.987, $p = 0.03$), black/blue (ANOVA, F = 7.236, $p = 0.002$), and yellow/orange (ANOVA,

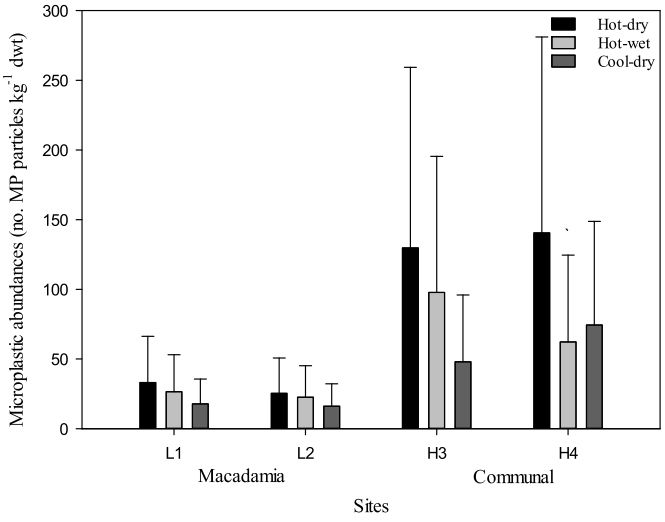

Fig. 2. Mean (± standard deviation) of microplastic density in sediments in macadamia and communal reservoirs. Abbreviations: L – low human activities, H – high human activities.

F = 6.769, $p = 0.003$). Moreover, significant differences were observed across reservoirs × seasons interaction for yellow/orange (ANOVA, F = 4.190, $p = 0.003$). Pairwise multiple comparisons highlighted significant differences across reservoirs for red/pink, i.e., L1 vs H3 ($p = 0.002$), L1 vs H4 ($p = 0.037$), L2 vs H3 ($p < 0.001$), L2 vs H4 ($p = 0.004$), white, i.e., L1 vs H3 ($p = 0.004$), L2 vs H4 ($p < 0.001$), black/blue, i.e., L1 vs H4 ($p = 0.01$), L2 vs H3 ($p = 0.04$), L2 vs H4 ($p = 0.001$), yellow/orange, i.e., L1 vs H3 ($p = 0.01$), L1 vs H4 ($p < 0.001$), L2 vs H4 ($p = 0.01$), and green, i.e., L1 vs H4 ($p = 0.001$), L2 vs H4 ($p < 0.001$), H3 vs H4 ($p = 0.003$). Furthermore, pairwise multiple comparisons highlighted significant differences across seasons for white, i.e., hot–dry vs hot–wet ($p = 0.004$), black/blue, i.e., cool–dry vs hot–dry ($p = 0.002$), hot–dry vs hot–wet ($p = 0.045$), and yellow/orange, i.e., cool–dry vs hot–dry ($p = 0.002$).

From the observed 2–5 mm microplastic particles, suspected particles underwent ATF-FTIR analysis resulting in five polymer types: 31.0% polypropylene, 30.0% polystyrene, 15.0% polydimethylsiloxane, 12.0% polyvinyl chloride, and 12.0% polyethylene.

Based on Pearson correlations, there was no significant relationship ($p > 0.05$) observed between environmental parameters and microplastic particles, supporting the null hypothesis of a lack of effect of temperature, pH, conductivity and total dissolved solids on microplastic densities. Positive, non-significant correlations were observed for conductivity ($r = 0.57$, $p = 0.05$) and TDS ($r = 0.61$, $p = 0.12$), whereas negative significant correlations were observed for pH ($r = -0.17$, $p = 0.004$) and temperature ($r = -0.24$, $p = 0.06$).

4. Discussion

Various literature has extensively explored anthropogenic impacts of microplastics in freshwater ecosystems, but the literature on the presence of microplastics as contaminants in regions of South Africa is still emerging. The present study aimed at adding inland water system microplastic inputs and pollution knowledge to existing literature by seasonally assessing microplastic densities in sediments from small recreational reservoirs associated with human activities (i.e., low, high). The results revealed that microplastics were present in all examined sediments across reservoirs and seasons, indicating the extensive dispersion of microplastics in small recreational reservoirs, however, this pollution varied across reservoir types. The variation in microplastics is likely due to human activity and rainfalls associated with increased run-off. As indicated by Xia et al. (2020), rainfall is a significant environmental predictor of microplastic pollution in inland waters. Furthermore, a study

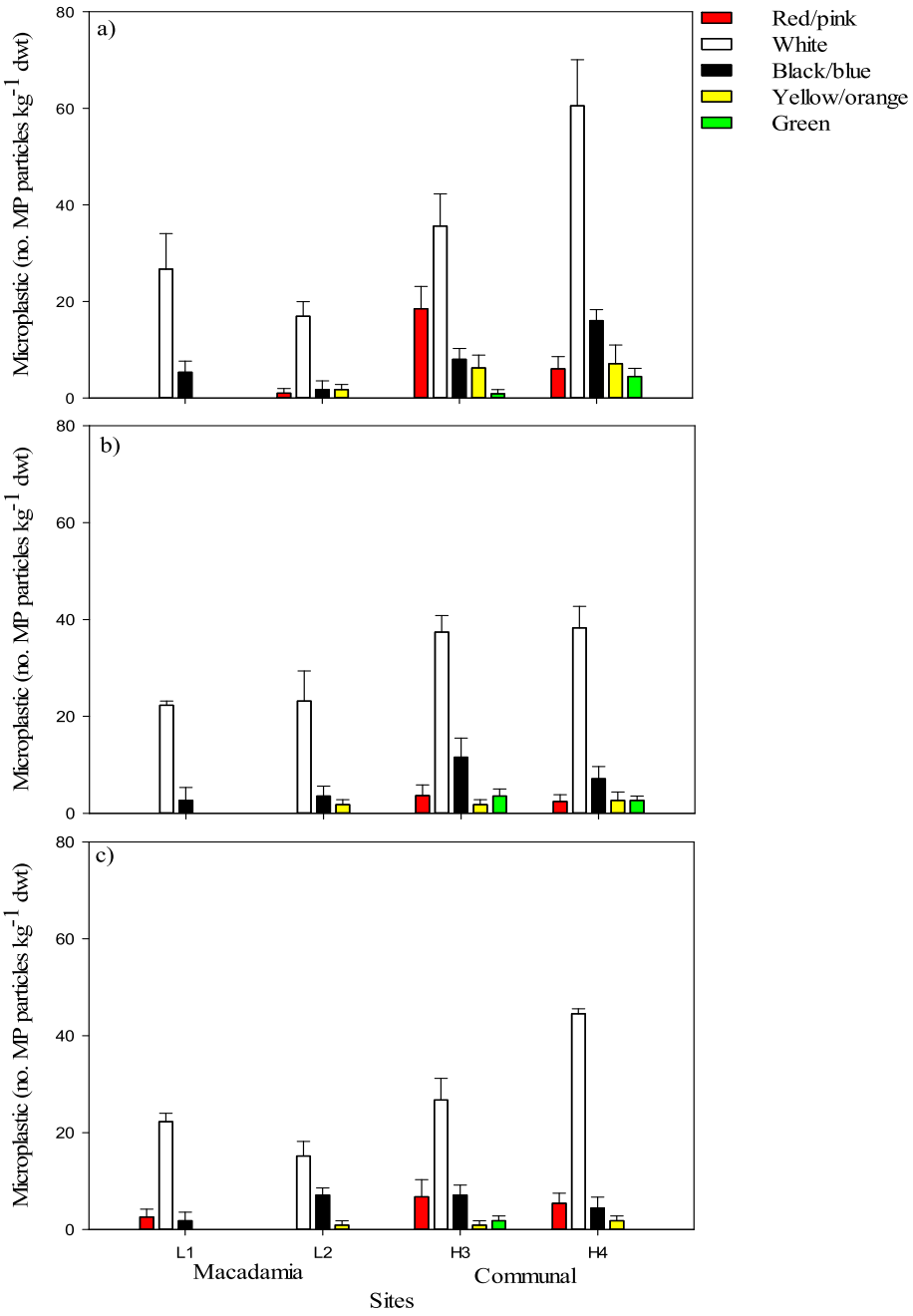

Fig. 3. Mean (± standard deviation) of microplastic particle types across seasons: (**a**) hot–dry, (**b**) hot–wet, and (**c**) cool–dry in macadamia and communal reservoirs. Abbreviations: L – low human activities, H – high human activities.

by Figueiredo and Vianna (2018) demonstrated seasonal variation in microplastic density with rainfall influencing the variation. No significant relationships were observed between environmental parameters and microplastic densities, indicating that microplastic pollution is often context-independent.

Microplastics were significantly higher in communal area reservoirs during the hot–dry season and lower in macadamia orchards during the cool–dry season. We surmise that the source of microplastics in the communal areas might be from discarded litter from the surrounding residences, cosmetics, cleaning products, and synthetic fishing gear, such as nets, ropes and pots. Cosmetic and cleaning products resulting from human activities are regarded as a major contributor of microplastic pollution in reservoirs (Fan et al., 2021). However, in macadamia reservoirs, the source of microplastics might be mainly from agricultural plastic products. For instance, macadamia orchards are most active during the nut collection period, which is from March to July. During this collection period, plastic products can be used for harvest and storage purposes. Agricultural activities have been attributed to microplastic pollution through decomposition of agricultural equipment, sewage containing fibres from clothes, fishing gears, atmospheric deposition, surface runoff, and chemical packaging via bags (Claessens et al., 2011; Browne et al., 2011).

The hot–dry season may be considered a major sink for microplastic pollutants in recreational reservoirs, with human activities along the shoreline driving the microplastic numbers (Dalu et al., 2019). The high microplastic densities during the hot–dry season suggest that the microplastics were stored in the sediments prior to being distributed to nearby river systems, which may be related to less rainfalls, higher evaporation, and thus higher sediment loads (Xia et al., 2021). The cool–dry season was associated with decreased microplastic densities,

likely in relation to reduced human activities, rainfall, and flow rate, whereby microplastics in the surface water of reservoirs are more likely to be in suspension and exported (Watkins et al., 2019). Cool–dry seasons are characterised by low rainfall and dry weather (drier than the hot–dry and hot–wet) in the study area, and thus had reduced numbers and distribution of microplastics (which can move easily with water and wind). Communal reservoirs can be regarded as the major source of microplastics to the neighbouring river system as they act as a sink during the hot–dry season and are distributed during heavy rainfalls in the hot–wet seasons, thus reducing microplastics in the reservoir.

The colour of microplastics can provide information on their origin. For instance, dyed plastic can result from packaging materials, and coloured microbeads and pellets can originate from cosmetic products (Hamidian et al., 2021). In the present study, white microplastics made up the majority of microplastic in reservoirs associated with both low and high human activities. Nevertheless, a rich variety of colours were recovered. Several studies (e.g., Mbedzi et al., 2020; Vidyasakar et al., 2020; Chouchene et al., 2021) assessing microplastics in sediments have found white microplastics as the most dominant. However, given that plastics are very susceptible to degradation processes, colourless or transparent microplastic particles could potentially be overlooked during extraction or identification processes and end up being identified as white. We found a variety of polymer types, with polypropylene and polystyrene being the most dominant. Similar results were observed by Klein et al. (2015) and Efimova et al. (2018). As stated by Maddah and Hisham (2016), polypropylene is the most widely used plastic material in industry, along with polystyrene (Ho et al., 2018). Despite the colour and type, microplastics are difficult to identify, and are readily ingested by aquatic organisms because of their microscopic size, resulting in ecotoxicological effects from primary producers to humans (Huang et al., 2021). Thus, it is essential to comprehend the cumulative toxic effects of microplastics in various polluted aquatic environments (Paul-Pont et al., 2018; Vo and Pham, 2021).

In aquatic environments, microplastics are currently of global concern, whether they originate directly from industrial and household products or from the degradation of larger plastics (Xu et al., 2020; Sanganyado, Kajau, 2022; Yardy et al., 2022). These microplastics may have a negative impact on aquatic organisms because they are abundant in aquatic environments (Sanganyado et al., 2021). The capacity of microplastics to adsorb both organic and inorganic pollutants before releasing them into freshwater and marine systems raises additional concerns (Ma et al., 2020; Sanganyado et al., 2021). The ecotoxicological effects of microplastics on aquatic environments remain a cause for concern, as anthropogenic activities in communal areas and macadamia plantations continue to rise, leading to an increase in the use of plastic products (Wang et al., 2021). Microplastics, for instance, disperse differently in various compartments of the aquatic environment (i.e., water column and sediment), influencing the availability of microplastics to organisms at different trophic levels and/or occupying different habitats due to differences in shape and density (Ilyas et al., 2022). Accumulation of microplastics-associated contaminants may result in an increase in the potential risk of contaminant accumulation for higher trophic levels, including humans.

5. Conclusion

The current study demonstrated that microplastics are widespread in the sediments from small recreational reservoirs, but shaped by human activities (i.e., low, high). Results from the current study revealed significant differences in microplastic densities across small recreational tropical reservoirs and seasons associated with low and high human activities, supporting the hypothesis that human activities act as major source for microplastic contaminants and that seasonal variations influence microplastic distribution. Considering that there are many freshwater organisms with considerable trophic and commercial importance, understanding the occurrence and ecotoxicological effects of microplastics in inland freshwater ecosystems should be studied further. However, the current study provides baseline data for understanding microplastic pollution associated with recreational trophic reservoir sediments. Further studies should focus on understanding the transport and ecotoxicological effects of microplastics to aquatic organisms in these reservoirs. Furthermore, more studies are required over large spatiotemporal scales so as to better understand the occurrence of microplastic abundances and distributions.

Funding

We greatly acknowledge the financial support of the University of Venda Niche Grant (UID: FSEA/21/GGES/02) and National Research Foundation Grant (UID: 138206). Thendo Mutshekwa, Ross N Cuthbert and Tatenda Dalu acknowledge funding from the NRF Postgraduate Bursary (UID: 121348), Leverhulme Trust Early Career Fellowship (ECF-2021-001) and Stellenbosch Institute for Advanced Study fellowship, respectively.

Authors contributions

Thendo Mutshekwa: Data curation; Formal analysis; Investigation; Methodology; Software; Validation; Visualization; Writing – original draft; Writing – review & editing. **Linton F Munyai**: Investigation; Methodology; Validation; Visualization; Writing – original draft; Writing – review & editing. **Lutendo Mugwedi**: Supervision; Validation; Visualization; Writing – review & editing. **Ross N Cuthbert**: Conceptualization; Funding acquisition; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Writing – review & editing. **Farai Dondofema**: Funding acquisition; Investigation; Project administration; Resources; Supervision; Validation; Visualization; Writing – review & editing. **Tatenda Dalu**: Conceptualization; Data curation; Funding acquisition; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

Declaration of competing interest

The authors certify that they have no conflict of interest.

Acknowledgments

We thank Lutendo Phophi for assisting with sample collection.

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