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Nyumba-ya-Mungu Water Reservoir in Tanzania: Public Awareness About Plastic Use, Management, and Health Risks

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Abstract

Microplastics (MP) from mismanaged plastic waste pose growing threats to human health and ecosystems. The Nyumba-ya-Mungu Water Reservoir (NWR) in Tanzania is vulnerable to plastic pollution due to improper waste disposal and low public awareness. This study aimed to assess public knowledge, attitudes, and practices (KAP) on plastic use, waste management, and associated health risks around NWR. A cross-sectional survey was conducted involving 401 respondents. Data were collected through questionnaires and environmental observations. Quantitative data were analysed using SPSS and Excel for descriptive statistics and t-tests. Most respondents lacked adequate knowledge on plastic use (88%), waste management (77%), and health risks (83%). Positive attitudes toward plastic use were driven by cost-effectiveness (55%) and low awareness of their health hazards. Given the widespread improper plastic disposal practices observed in the study area, the

reservoir may be vulnerable to microplastic contamination, and some public health issues in the catchment could potentially be linked to such pollution. Enhancing public education on plastic hazards together with strict enforcement of the existing plastic waste management regulations are essential to mitigate health risks and protect NWR environmental integrity.

Keywords: microplastics, plastic use, plastic wastes, water reservoir, health effects, public health, waste management

1. Introduction

Plastics are widely utilized across various sectors, but their improper disposal has made microplastics (MP) a pressing global concern due to their detrimental effects on the environment and human health (Hale et al., 2020; Mogusu et al., 2022). MP are primarily generated from human activities, entering aquatic environments through mismanaged solid and liquid wastes arising from socioeconomic and domestic sources (Li et al., 2021; Jaafar et al., 2021; Garcés-Ordóñez et al., 2021). The situation is exacerbated by widespread plastic use, weak waste management infrastructure, and poor environmental awareness (Sharma, 2020). MP are thus considered a human-induced problem (Pahl and Wyles, 2017).

Addressing the MP crisis requires understanding various human dimensions, particularly consumers' knowledge, attitudes, and practices (KAP) regarding plastic use and disposal. Studies have shown that better-informed populations are more concerned and proactive about pollution-related issues. For example, Deng et al. (2022) emphasize the importance of assessing public awareness to reduce MP at the source. Similarly, a study by De Pretto et al. (2015) demonstrated that knowledge strongly correlates with concern and protective behavior, as seen in Malaysia during haze pollution. Further studies in Egypt and Thailand have found low levels of knowledge and high plastic usage, especially among individuals with limited education and lower socioeconomic status (Kasemsup and Neesanan, 2011; Hassan et al., 2023). Khanam et al. (2019) reported that schoolchildren, once educated about plastic harms, were willing to abandon plastic bags and raise awareness among peers.

MP can pose serious health risks after entering the human body through ingestion or inhalation and translocate into organs such as the lungs, liver, kidneys, and brain (Ding et al., 2018; Barceló et al., 2023). Associated health outcomes include endocrine disruption, reproductive harm, respiratory diseases, immune toxicity, and cancers (Blackburn, 2022; Lee et al., 2023; Winiarska et al., 2024). MP toxicity has been confirmed both through direct evidence in humans and extrapolated findings from model organisms (Hale et al., 2020). For instance, in the UK, MP recovered from human lung tissues were of known harmful plastics linked to asthma and cancer (Blackburn, 2022). The World Health Organization (n.d.) warns that plastic-related health risks persist throughout the plastic lifecycle, urging improved waste management and public awareness.

Although humans are both contributors to and victims of plastic pollution, it is not well established whether communities adequately understand the proper use of plastics, associated risks, and appropriate waste handling practices. This study examined public awareness and public health concerns related to plastic use within the catchment of the Nyumba-ya-Mungu

Water Reservoir (NWR) in Tanzania, a vital source of drinking water and food. To date, no studies have documented knowledge, attitudes, practices, or health implications associated with plastic pollution in this area, creating a critical evidence gap that constrains effective environmental and public health planning. Consequently, assessing community awareness and potential health risks was considered essential for informing targeted interventions and protecting both ecosystem integrity and human well-being.

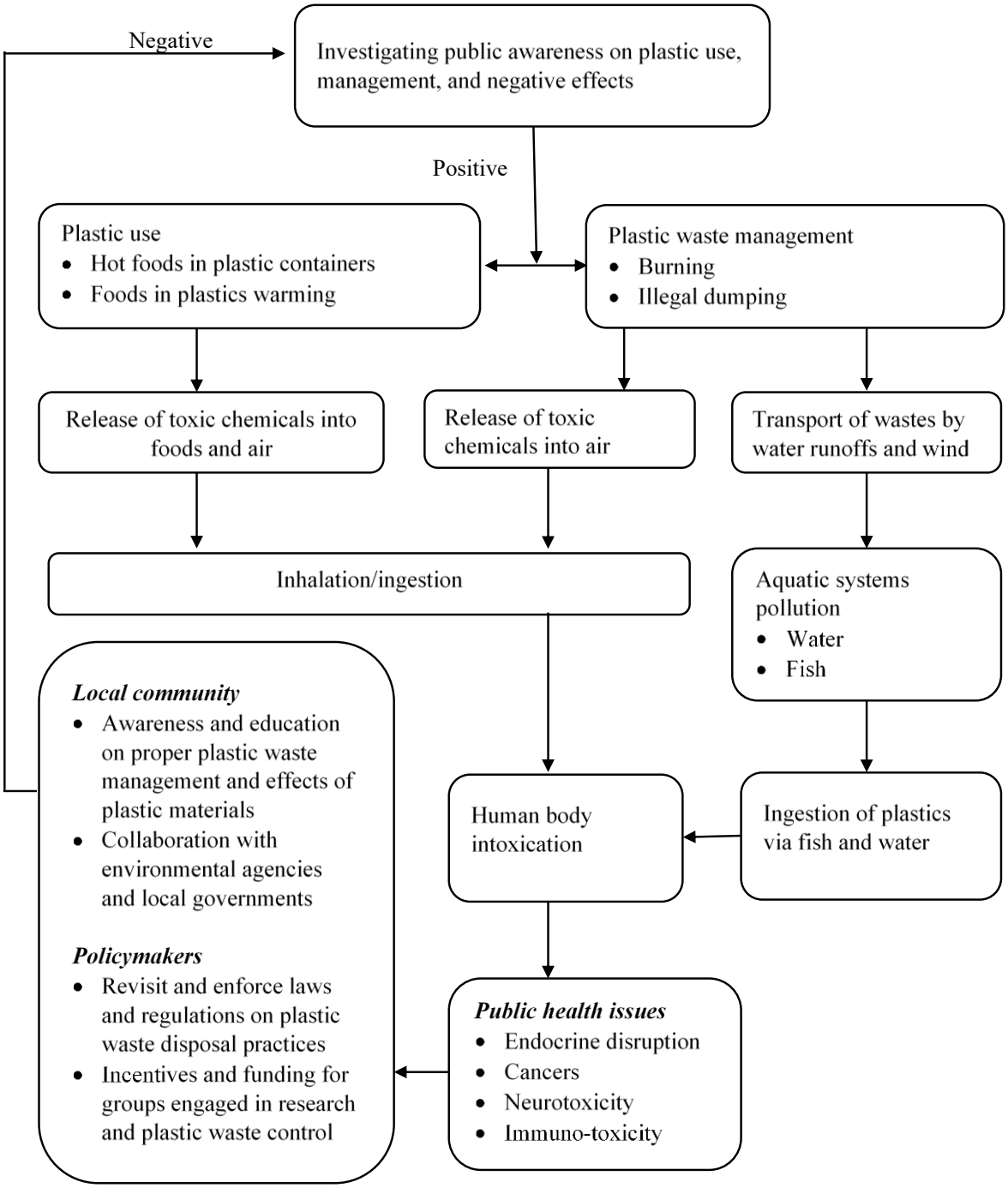

Figure 1. Theoretical framework of impacts of low awareness about proper plastic use, management, and health risks.

2. Materials and Methods

2.1 Description of the Study Area

Nyumba-ya-Mungu Water Reservoir (NWR), is an artificial lake located within the upper Pangani River Basin, situated between 3°49'33.0" S and 37°28'9.6" E, in Kilimanjaro Region, Northern-East Tanzania. The reservoir is fed by two main rivers: Kikuletwa River which originates from Mount Meru to the northwest, and the Ruvu River which flows from Lake Jipe to the north-east. FurthermoreNWR is an important fishery area in the region and almost the whole of its shoreline is utilized by fishermen with permanent settlements several meters from the reservoir's edge. The reservoir is drained by the Pangani River that empties in the Indian Ocean (IBA, 2001; Ikingura & Akagi, 2003). The questionnaire survey was conducted in the catchment of the NWR, covering its three bordering wards: Kirya and Lang'ata in Mwanga District and Mikocheni in Moshi District, as well as other locations within the catchment, including Soweto in Moshi Municipality and Kibosho, Kilema, and Marangu in Moshi District.

2.2 Research Design and Sampling

This study employed a cross-sectional survey design integrating questionnaires and environmental observation to assess public knowledge, attitudes, and practices regarding plastic use, waste management, and related health risks in the NWR catchment area. The questionnaire was translated from English into Swahili and pretested to ensure clarity and improve validity. It was administered to 401 local residents to capture community-level awareness and behaviors concerning plastic use and its potential health effects. Environmental observations were conducted across the catchment to document prevailing plastic use and disposal practices and to triangulate questionnaire findings. Both purposive and random sampling were applied: purposive sampling identified eligible participants, while random sampling selected respondents among those who met the inclusion criteria. Eligible participants were residents of the NWR catchment who could read and write English or Swahili, were from 14 years of age and above, and were willing to participate in the study. The sample size was determined using Smith's (2013) formula, which recommends a minimum of 386 respondents for large or unknown populations. The formula stands as follows $n=Z^2X(1\text{-}SD)/Sx^2$, where n= sample size, Z= z-score (=1.96), SD= standard deviation (=0.5), Sx= standard error (=0.05), at 95% confidence level. Additionally, prior to data collection, all necessary research permits were obtained from relevant government authorities. Ward executive officers facilitated rapport building with participants, and community meetings were held to explain the study objectives and assure adherence to research ethics.

2.3 Data Collection and Analysis

An observation checklist was employed to gather data on plastic use and management within the study area. photos were also taken to strengthen evidence. Quantitative data obtained from the questionnaires were processed and analyzed using SPSS, generating frequency and percentage distributions of responses. Additionally, correlational and t-tests were conducted

to assess statistical significance and relation of sets of data where applicable. Observational data were organized in recurring patterns in order to substantiate questionnaire data.

3. Results

3.1 Plastics in the Study Area

Participants residing around the NWR reported various types of plastics commonly used in their households, those frequently discarded in their residential areas, and the factors influencing plastic use (Table 1). The five most frequently used plastic items were plates (84.5%), buckets (77.8%), cups (75.1%), bowls (54.4%), and bottles (51.1%). Regarding commonly discarded plastics, bottles (85.5%) and plastic bags (67.6%) were most prevalent. Key factors driving plastic use included cost-effectiveness (54.9%), ease of handling (47.6%), durability (31.5%), availability (24.2%), attractiveness (8.2%), heat retention (5.0%), versatility (3.5%), and resistance to corrosion (2.0%). Additionally, a significant majority of participants (87.5%) reported the practice of using plastic containers to store and serve hot food, as detailed in Table 2 (section d).

Table 1. Plastics in use, factors fueling plastic use, and plastics commonly dispersed around NWR (Frequency (Percentage)).

(a) Plastics in use		***(b) Fueling factors***		***(c) Dispersed plastics***	
Plates	339(84.5)	Cost effectiveness	220(54.9)	Bottles	331(85.5)
Buckets	312(77.8)	Manageability	191(47.6)	Bags	271(67.6)
Cups	301(75.1)	Durability	128(31.1)	Covers	142 (35.5)
Bowls	218(54.4)	Availability	97(24.2)	Utensils	100 (24.9)
Bottles	205(51.1)	Attractiveness	33(8.2)		
Bags	165(41.1)	Heat-preservation	20(5.0)		
Basins	158(39.4)	Versatility	14(3.5)		
Closed containers	55(13.7)	Corrosion resistance	8(2.0)		
Covers	48(12.0)	Easy decomposition	6(1.5)		
Jugs	34(8.5)	Heat resistant	5(1.2)		
Table and chairs	29(7.2)	Environment friendly	5(1.2)		
Water tanks	27(6.7)	Health friendly	3(0.7)		
Spoons	27(6.7)	Heat conductor	2(0.5)		

3.2 Public Awareness on the Negative Effects of Plastics to Human Health

When asked about the harmful effects of plastics on human health, 52.1% of respondents acknowledged awareness, while 47.9% reported having no knowledge of such effects (Table 2, part c). Furthermore, a significant majority (82.8%) indicated that they had not received any formal information regarding the health risks associated with plastic use (Table 2, part b). In identifying specific negative effects (Table 3, part a), respondents cited environmental

pollution (45.9%), diseases in general (30.9%), cholera (23.7%), cancer (9.5%), lung problems (8.2%), toxicity (7.2%), malaria (6.7%), and loss of soil fertility (1.5%) as the most recognized impacts.

Table 2. Responses concerning awareness on issues of environmental responsibility and adverse effects of plastics (Frequency (Percentage)).

QUESTION	***RESPONSE***		
	Yes	*No*	*Not Sure*
(a) Is environmental responsibility more for some?	45 (11.2)	301 (75.1)	55 (13.7)
(b) Are you sensitized on plastic adverse effects?	69 (17.2)	332 (82.8)	0 (0.0)
(c) Do Plastics have negative effects?	209 (52.1)	192 (47.9)	0 (0.0)
(d) Do you serve hot foods in plastics?	351 (87.5)	50 (12.5)	0 (0.0)
(e) Do some throw wastes in water-runoffs?	220 (54.9)	134 (33.4)	47 (11.7)
(f) Do you eat fish of NWR?	375 (93.5)	26 (6.5)	0 (0.0)
(g) Is NWR water used for drinking and cooking?	301 (75.1)	27 (6.7)	69 (17.2)

Table 3. Awareness on negative health effects; and disseminated information on the negative effects of plastics (Frequency (Percentage)).

(a) Negative effects		***(b) Disseminated information***	
Environmental pollution	184 (45.9)	Cause diseases	102 (25.4)
Diseases	121 (30.2)	Environmental pollution	98 (24.4)
Cholera	95 (23.7)	Loss of organisms	28 (7.0)
Killing living organisms	62 (15.5)	Loss of soil fertility	10 (2.5)
Cancer	38 (9.5)		
Respiratory problems	33 (8.2)		
Toxification	29 (7.2)		
Malaria	27 (6.7)		
Diarrhea	19 (4.7)		
Loss of soil fertility	6 (1.5)		

3.3 Public Awareness on the Appropriate Methods for Plastic Waste Management

The most common plastic waste management practices reported around the study area were burning (86.5%) and disposal at dumpsites (45.6%), as presented in Table 4 (part a). Field observations confirmed widespread plastic burning and environmental littering, with a majority of participants (54.9%) acknowledging that plastics were often discarded into water runoffs (Table 2, part e). When asked to identify what they considered appropriate waste management practices from those currently in use, burning remained the most cited method (76.6%), followed by reduction (37.9%), recycling (31.7%), and reusing (30.4%), indicating a notable shift between perceived and practiced methods (Table 4, part b). Statistical analysis

showed a significant increase in support for the reduce, reuse, and recycle (3Rs) methods ($p = 0.039$), while practices such as burning, dumping, and disposal into rivers showed a non-significant decrease in perceived appropriateness ($p = 0.084$). When dumpsites, burying, reuse, reduction, and recycling were considered appropriate plastic waste management methods, analysis of practice and knowledge scores using Pearson's correlation revealed a very weak positive linear relationship ($r = 0.1184$). This suggests that although some level of awareness exists, it is not strongly reflected in the public's actual waste management practices.

Table 4. Existing practices and community opinions on appropriate plastic waste management methods

Category	***Method***	***Practice (%)***	***Knowledge about method as (%)***	
			Proper	***Improper***
Proper	Burying	14.7	13.5	86.5
	Dumpsite use	45.6	27.7	72.3
	Re-cycle	17.5	31.7	68.3
	Re-use	20.4	30.4	69.6
	Reduce	19.7	37.9	62.1
Improper	Burning	86.8	76.6	23.4
	Throwing far away	9.0	4.2	95.8
	Throwing in water run-offs	3.7	2	98

3.4 Contributing Factors to Poor Waste Management in the Catchment Area

The study revealed substantial evidence of plastic mismanagement and limited adherence to waste management regulations in the NWR catchment area. When participants were asked to identify contributing factors, the majority (70.4%) pointed to low awareness and irresponsible behavior (Table 5). Interestingly, most participants (85.5%) did not view lack of infrastructure as a major constraint. Despite these challenges, 75.1% acknowledged that environmental stewardship is a shared responsibility (Table 2, part a).

Table 5. Factors contributing to poor plastic waste management; and less-than-high adherence to plastic waste management regulations around NWR (Frequency (Percentage)).

Factor	***(a) Poor waste management***	***(b) Less-than-high adherence to regulations***
Poor knowledge	285 (71.1)	279 (69.6)
Irresponsibility	180 (44.9)	173 (43.1)
Lack of infrastructures	58 (14.5)	67 (16.7)
Not sure	13 (3.2)	18 (4.5)

4. Discussion

4.1 Plastic use patterns and drivers around the reservoir

The findings of this study indicate that plastic use around the Nyumba-ya-Mungu Water Reservoir (NWR) is deeply embedded in everyday household activities, reflecting a pattern widely observed in low- and middle-income settings. Plastics are predominantly used for food handling, storage, and water-related domestic tasks, largely because of their affordability, durability, and ease of handling. Similar observations have been reported globally, where plastics are favored not out of preference but necessity, particularly where alternatives are limited or economically inaccessible (Hale et al., 2020; Kabir et al., 2022; Khan et al., 2022; De Sousa, 2023; Rahman et al., 2025). Importantly, the factors motivating plastic use in the study area mirror global trends, with economic convenience outweighing environmental and health considerations. However, the identification of plastics as "environmentally friendly," "health friendly," or "easily decomposable" by some participants highlights persistent misconceptions about plastic properties. Such misunderstandings have been documented elsewhere and are often linked to inadequate or generalized environmental messaging that fails to communicate the specific risks associated with plastics and microplastics (Kelly et al., 2020; Sharma et al., 2021). For instance, De Sousa (2023) emphasizes that low awareness of the adverse effects of plastics contributes to a false sense of safety among users.

The dominance of bottles and plastic bags among dispersed wastes suggests that single-use and packaging plastics remain the primary contributors to environmental pollution. This pattern aligns with global litter assessments, which consistently identify these items as the most prevalent plastic debris in aquatic and terrestrial ecosystems (Velis & Cook, 2021). Their widespread dispersal around NWR raises concerns about sustained inputs of plastics into the reservoir through runoff and wind-driven transport.

4.2 Public Awareness on Plastic Health Effects to Humans

Although most participants expressed a sense of shared environmental responsibility, this awareness did not translate into safer behaviors. Limited sensitization on the adverse effects of plastics appears to undermine informed decision-making and reinforces risky practices, particularly the widespread use of plastic containers for hot food. Similar practices have been reported across Africa and Asia and are increasingly associated with elevated risks of microplastic ingestion and chemical leaching. Scientific evidence shows that thermal energy from hot foods can accelerate plastic degradation, leading to the formation of microplastics (Chen et al., 2020) and the leaching of toxic additives into food (Babayemi et al., 2019; Banerjee & Khan, 2020; Liu et al., 2022; Hassan et al., 2023). Furthermore, Banerjee& Khan (2020) provide evidence that frequent consumption of food and drinks stored in plastic containers may increase cancer risk due to leached harmful additives.

The heavy reliance on NWR for fish consumption and domestic water further amplifies the public health concerns. Aquatic systems receiving plastic waste are known to accumulate microplastics, which can enter food webs and potentially affect human health (Ding et al., 2018; Wright & Kelly, 2017; Mogusu et al., 2022). In this context, low awareness, unsafe plastic-use practices, and environmental dependence converge to heighten vulnerability

within the catchment population.

4.3 Public Awareness on the Appropriate Methods for Plastic Waste Management

The evident disparity between plastic waste management practices observed around the NWR and those regarded as appropriate indicates low public awareness of proper waste management methods. For example, in this study only 23.4% of respondents acknowledged that burning plastics is harmful, highlighting a widespread lack of awareness of the serious environmental and health consequences associated with this practice. Burning plastics releases hazardous substances such as bisphenols, phthalates, dioxins, and furans, which can harm neural, endocrine, and reproductive systems and contribute to cancer (Velis and Cook, 2021; Sarkingobir, 2021; Cosier, 2022). Field observations confirmed widespread plastic mismanagement, particularly through illegal dumping in bushes, along pathways, and into waterways. During rainfall events, surface runoff was identified as the primary pathway transporting plastic waste into the reservoir. Such pollution poses a direct threat to water quality and to the health of surrounding communities, many of whom depend on the reservoir for drinking water and fish consumption. Our findings are consistent with those reported by Nahabi (2023) in Bwaise, Uganda, where improper plastic waste disposal was directly associated with inadequate environmental education.

It was also observed that, despite the Tanzanian government's ban on plastic carrier bags in 2019 and the strengthened enforcement in 2023 (United Republic of Tanzania, 2019; 2023), plastic bag pollution remains widespread in the NWR catchment, indicating weak enforcement at the local level. The findings highlight the urgency for both community education and stronger government intervention to effectively manage plastic waste.

The study underscores the need for context-specific interventions that move beyond general environmental awareness toward targeted education on plastic-related health risks, alongside strengthened enforcement of waste management regulations. These findings align with global evidence emphasizing that behavioral change is most effective when supported by consistent policy enforcement, accessible alternatives, and sustained community engagement (Evode et al., 2021). Further studies focusing on community lifestyle and their potential links to plastic-related health problems are needed to establish clear cause-effect relationships.

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Authors contributions

Fr. Cornelius B. Mushumbusi contributed to the conceptualization and organization of the research, data collection, manuscript preparation, writing, editing, and revision.

Dr. Emmanuel O. Mogusu provided supervision and contributed to manuscript editing and

revision.

Prof. Robert A. Max contributed to methodological clarification, supervision, manuscript editing and revision, and served as the corresponding author.

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Competing interests

The authors declare that there are no conflicts of interest associated with this study.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Macrothink Institute.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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