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Analysis of Major Solid Waste Dumpsites and its Effects on Water Sources in Mubi Town, Nigeria

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Abstract

This study analyzed the spatial distribution of major solid waste dumpsites and their effects on water sources in Mubi Town, Nigeria. A descriptive and analytical research design was employed, incorporating Geographic Information System (GIS) techniques to map dumpsites and assess their proximity to water sources. Primary data, including Global Positioning System (GPS) coordinates, water quality samples, and major water sources were collected, while secondary data such as images and maps of the study area were obtained from satellite imagery and environmental reports. Findings revealed that 66 major dumpsites were scattered across different locations, with significant clustering in Shuware, Lokuwa, and Barama. Many dumpsites were located within less than 50 meters of key water sources, increasing the risk of contamination. Water quality assessments indicated high levels of pollutants in the water sources, exceeding World Health Organization (WHO) standards, posing a threat to public health. Poor waste management infrastructure contributed to widespread illegal dumping, further exacerbating water pollution. The study recommended the establishment of a government-led waste management agency, private sector participation, and increased community involvement in waste collection and disposal. In addition, it emphasized the need for public awareness campaigns on the dangers of improper waste management.

Introduction

The increasing amount of Municipal Solid Waste (MSW) due to rising populations in developing countries has become a significant threat to the environment, society, and water supply sources in expanding towns like Mubi Metropolis (UNEP, 2024). Solid waste has emerged as a major environmental issue, particularly in developing nations, where ineffective waste management systems exacerbate pollution problems (Kaza et al., 2023). Solid waste consists of unwanted solid materials generated from residential, industrial, and commercial activities. It is categorized based on origin (domestic, industrial, commercial, construction, institutional), contents (organic material, glass, metal, plastic, paper), or hazard potential (toxic, non-toxic, flammable, radioactive, infectious) (World Bank, 2024). Effective solid waste control reduces adverse effects on human health and the environment while also promoting economic development and improving quality of life. The waste management process includes monitoring, collection, transport, processing, recycling, and disposal (Rahman et al., 2024).

The improper disposal of solid waste in Mubi Metropolis has resulted in serious contamination of water sources, posing severe risks to both public health and the environment. Many households and businesses dispose of waste directly into rivers, streams, and drainage systems, leading to blockages, water stagnation, and pollution (Olowoporoku & Akande, 2023). Solid waste materials such as plastics, cans, and polythene bags do not decompose easily, creating long-term environmental hazards. Leachate from decomposing waste at open dumpsites infiltrates the groundwater and nearby surface water sources, introducing toxic substances such as heavy metals, pathogens, and harmful chemicals (NCBI, 2024). These contaminants degrade the quality of drinking water, making it unsafe for consumption and increasing the prevalence of waterborne diseases such as cholera, typhoid, and dysentery (WHO, 2023).

Monitoring solid waste has become an urgent environmental concern globally. In many countries, waste management has traditionally followed the waste hierarchy, prioritizing waste minimization and cleaner technology over recycling, incineration, and landfilling (World Bank, 2024). Historically, waste was collected using packer dump trucks and disposed of at landfills. However, as urban areas expand and landfill space decreases, inefficient waste disposal methods have led to increasing environmental pollution. The practice of open dumping in water bodies, abandoned lands, and unauthorized sites without proper treatment has worsened contamination and health-related problems in urban areas (Olawale et al., 2024). In Nigeria, urban solid waste is composed of organic materials, plastics, polythene, cans, metals, bottles, glasses, clothes, shoes, and ceramics. Household waste has also been found to contain hazardous materials such as expired drugs, batteries, broken glass, syringes, and electronic waste, which further contribute to environmental and health hazards (Adamu & Yusuf, 2024).

The effect of solid waste on water sources in Mubi Metropolis is profound. The unregulated dumping of waste near rivers and boreholes has increased water contamination, leading to the spread of waterborne diseases and ecosystem degradation (Rahman et al., 2024). Waste accumulation near drainage channels obstructs water flow, causing flooding during heavy rains and increasing the risk of sewage overflow into clean water sources (UNEP, 2024). Open dumping sites attract rodents, mosquitoes, and flies, which further contribute to the spread of vector-borne diseases (WHO, 2023). In addition, open burning of waste releases toxic pollutants into the air, affecting air quality and causing respiratory problems among residents (NCBI, 2024).

Community waste disposal remains a major concern in developing nations, where poverty, rapid population growth, and inadequate government policies hinder effective waste management (UNEP, 2024). A generalized approach is necessary to address waste management challenges, including the integration of computerized systems such as Geographic Information Systems (GIS) and Remote Sensing for optimal waste management planning (Kaza et al., 2023). These technologies can be used to map waste generation hotspots, identify appropriate landfill locations, and monitor waste disposal trends for sustainable urban waste management (Olowoporoku & Akande, 2023).

The rapid urbanization in Mubi Metropolis has increased the consumption of natural resources and led to a surge in waste generation. Uncontrolled waste disposal has resulted in severe freshwater pollution, with waste materials blocking natural water channels and contaminating underground water (World Bank, 2024). Stagnant water in discarded plastic containers, cans, and waste piles provides breeding grounds for mosquitoes, contributing to the spread of malaria and other vector-borne diseases (WHO, 2023). Leachate from dumpsites, containing hazardous chemicals, infiltrates surface and groundwater sources, making them unsafe for human consumption and agricultural use (NCBI, 2024). Open dumping sites also encourage rodent infestation, leading to the spread of diseases such as leptospirosis (Rahman et al., 2024). In addition, uncontrolled burning of waste releases toxic gases, worsening air pollution and respiratory ailments among residents (Adamu & Yusuf, 2024).

Despite the availability of waste processing technologies such as composting, polythene recycling, scrap metal recovery, and paper recycling, poor waste handling logistics remain a major barrier to effective waste management in Mubi Metropolis (Kaza et al., 2023). To address these challenges, it is necessary to develop comprehensive waste handling strategies that ensure proper waste collection, transportation, and disposal (Olawale et al., 2024). The study aims to contribute to sustainable solid waste management in Mubi Town by providing geospatial analysis of dumpsites and their proximity to water sources, facilitating the development of policies for better waste disposal practices (Rahman et al., 2024).

The increasing population, limited waste disposal facilities, and indiscriminate waste dumping in Mubi Town have resulted in a widespread environmental and public health crisis (UNEP, 2024). The absence of designated dumpsites has led to the emergence of multiple scattered waste sites, further complicating waste management (World Bank, 2024). By adopting GIS-based waste monitoring, this study hopes to facilitate the development of sustainable waste management strategies, which can be extended to cover other urban areas in Adamawa State (Olowoporoku & Akande, 2023).

METHODOLOGY

The Study Area

Mubi Town is the Head quarter of Mubi North Local Government Area which is geographically located between the Latitudes 10°05', and 10°30'N and the Longitudes 13°10' and 13°30'E of the Greenwich Meridian (Yohanna, & Nuhu, 2011). It is situated on the western flanks of the Mandara Mountains which forms both their drainage system and relief (Yonnana, Mohammed, and Oliver, 2020b). The area is bounded internationally by the Cameroon Republic on the east side and within the State by Michika Local Government Area to the north, Hong Local Government Area to the West, and Maiha Local Government Area to the south. The study area occupies land of 903km^2.

Research Design

The study adopted a descriptive and analytical research design, incorporating a quantitative approach to examine the spatial distribution of major solid waste dumpsites and their effects on water sources in Mubi Town. Geographic Information System (GIS) techniques were utilized to map the dumpsites and analyze their proximity to water sources. This design enabled a detailed assessment of the relationship between waste disposal practices and water quality degradation (Creswell, 2014). Furthermore, the research design integrated field surveys, laboratory analysis, and GIS-based spatial analysis to ensure a comprehensive evaluation. The combination of these methods provided insights into the extent of water contamination and allowed for effective visualization of affected areas (Yin, 2018).

Data Sources and Types

The study relied on both primary and secondary data for a comprehensive investigation. Primary data included geospatial data (GPS coordinates of dumpsites and water sources), water quality samples, and field observations. These data sources were essential for assessing the direct effect of waste disposal on water quality (Silverman, 2016). Secondary data were obtained from satellite imagery, environmental reports, historical water quality records, and relevant policy documents. These datasets provided background information on waste management trends and regulatory frameworks, aiding in the contextual analysis of water contamination risks (EPA, 2020).

Sampling Technique

Multi-stage sampling technique was employed to ensure representative data collection. Major dumpsites were identified using GIS mapping and field surveys. Next, water sources within a 500m to 1km radius of the dumpsites were selected for water quality testing. This approach ensured that the study captured potential contamination zones effectively (Kothari, 2004).

Materials/Equipment

The study utilized various materials and equipment for data collection and analysis. Field survey tools included GPS devices for location mapping, digital cameras for photographic documentation (Longley et al., 2015). For water quality analysis, instruments such as pH meters, turbidity meters, dissolved oxygen meters, and atomic absorption spectrometers (AAS) were used. These tools facilitated the detection of pollutants, including heavy metals and microbial contaminants, providing reliable data on water contamination levels (APHA, 2017).

Method of Data Collection

Data were collected through field surveys, water sampling, and GIS-based analysis. GPS coordinates of major dumpsites and water sources were recorded to determine their spatial relationships. Water samples were collected from boreholes, wells, rivers, and streams, and analyzed for parameters such as pH, turbidity, heavy metals, and microbial contamination (Silverman, 2016).

Method of Data Analysis (GIS Analysis)

The data were analyzed using GIS spatial analysis and water quality assessment techniques. ArcGIS 10.7 was used to create geospatial maps of dumpsites and their proximity to water bodies, while buffer analysis was applied to determine contamination risk zones (Burrough & McDonnell, 2015). For statistical analysis, descriptive statistics summarized water quality parameters. Water quality results were compared with WHO standards to evaluate pollution severity (Table 1). The findings were then visualized using GIS-generated maps to highlight high-risk areas (UNEP, 2018).

Table 1: The World Health Organization (WHO) Standard Limits for Common Water Quality Parameters

Parameter	WHO Standard Limit	Unit
Dissolved Solids (TDS)	≤ 1000	mg/L
Biochemical Oxygen Demand (BOD)	≤ 5	mg/L
Electrical Conductivity (EC)	≤ 1400	µS/cm
Temperature	Natural Range (20–30°C)	°C
Nitrate (NO_3)	≤ 10	mg/L
Phosphate (PO_4)	No specific limit for drinking water	mg/L
Calcium (Ca)	≤ 75	mg/L
Magnesium (Mg)	≤ 50	mg/L
Ph	6.5–8.5	-
Chloride (Cl)	≤ 250	mg/L
Sulfite (SO_3)	Not explicitly defined	mg/L

Source: World Health Organization (WHO). (2024)

RESULTS AND DISCUSSION

Table 2 presented the locations of major solid waste dumpsites in Mubi Town, including the specific coordinates (both easting and northing) for each site. On disposal of the solid waste (Refuse), the study revealed that there are sixty (66) major disposal points including the vacant, refuse dumps, gutters, on the streets and in the river banks. The methods of disposal of solid wastes by the residents in the study area are burning and dumping. Field observation revealed that dumping of solid wastes indiscriminately is appropriately evident. The wastes according to the research make the environment uncomfortable. Most of the respondents disclosed that solid waste generated are not disposed away regularly by the government and relevant stakeholders. It showed a comprehensive listing of dumpsites scattered across different localities in the town. The dumpsites were distributed across various areas such as Arhan Kunu, Sabon Pegi, Yelwa, Kwachifa, Kabang, Wuro Jibir, Shuware, Lokuwa, Kolere, Tudun Wada, and Barama. These localities were some of the main areas in Mubi where waste was disposed of. The large number of locations suggested that solid waste disposal had been a decentralized process, with numerous points of collection and dumping. Many dumpsites were clustered around specific regions, such as Shuware, which had several dumpsites located close to each other. This indicated that some parts of the town had been more heavily impacted by waste disposal, likely due to higher population densities or limited waste management infrastructure.

Mshelia et al. (2019) and Jones (2020) have shown that unregulated or poorly managed dumpsites often appear in densely populated areas, leading to environmental degradation and health risks, which is consistent with the clustering of dumpsites in areas like Shuware and Lokuwa in Mubi. The precision of the geographic coordinates provided in table 1 mirrors the use of Geographic Information Systems (GIS) in other studies, such as Miller (2018), which emphasized the importance of accurate mapping for monitoring waste disposal. In line with the research of Khan and Patel (2021), the recurrence of dumpsites in specific locations, such as Shuware, Garden City and Barama, likely indicates insufficient waste management infrastructure in these areas. This pattern was also documented by Adams et al. (2017), who noted that areas with higher numbers of dumpsites often correlate with limited access to formal waste collection services.

Furthermore, the implications for public health, highlighted in the study by Lee and Zhang (2020), are evident in Mubi Town, as waste mismanagement contributes to health risks such as respiratory diseases and contamination of local water sources. These observations suggest that Mubi Town may face similar challenges in managing solid waste, and as seen in previous studies, targeted interventions in these specific locations could help mitigate the environmental and health impacts associated with improper waste disposal.

Table 2: Location of Major Solid Waste Dumpsites in Mubi Town

S/N	**Names of Major Dumpsites**	**Locations of Major Dumpsites**	
	Locality	Nothing	Easting
1	ArhPan Kunu	1135771.22	307172.61
2	Arhan Kunu	1135580.8	307402.67
3	Arhan Kunu	1135536.77	308222.59
4	Sabon Pegi	1135107.1	308347.83
5	Sabon Pegi Pri School	1135549.96	308474.95
6	Yelwa	1135737.2	308643.04
7	Yelwa	1136082.05	308656.05
8	Kwachifa	1136231.97	308809.98
9	Kwachifa	1136571.66	308812.2
19	Sabon Pegi	1134819.09	308536.93
11	Sabon Pegi	1134819.09	308536.93

12	Kabang	1134887.86	308727.2
13	Kabang	1134894.13	308799.33
14	Kabang	1134807.41	309133.78
15	Kabang	1134881.69	309424.07
16	Near Abattoir	1136141.03	309551.31
17	Wuro Jibir	1135313.42	309704.1
18	Wuro Jibir	1135340.51	309782.24
19	Wuro Jibir	1135387.9	309828.64
20	Yen Gwanjo	1135426.54	309929.79
21	Shuware	1136132.03	310003.25
22	Shuware	1136276.22	310276.34
23	Shuware	1136296.67	310400.59
24	Shuware	1136480.98	310268.08
25	Shuware Garden City	1136573.36	310725.04
26	Shuware	1136372	310635
27	Shuware	1136309.99	310779.29
28	Shuware	1136258	310854
29	Shuware Garden City	1136573.36	310725.04
30	Shuware Garden City	1136553.33	311077.97
31	Shuware Garden City	1136520.45	311328.54
32	Shuware Garden City	1136386.4	311421.66
33	Lokuwa	1136291.34	311574.43
34	Lokuwa	1136504.08	311787.36
35	Lokuwa	1136536.53	311771.72
36	Lokuwa	1135908.89	311786.16
37	Lokuwa	1135935	311879
38	Lokuwa	1135946.72	311932.36
39	Lokuwa	1135996.85	312063.91
40	Lokuwa	1135673.66	312050.74
41	W. Patuji	1135349.3	312137.3
42	W. Patuji	1134966.35	311612.39
43	B Ball Court	1134973.23	311490.32
44	Filin Ball	1135043.08	311520.67
45	Shuware	1136081.42	311125.52
46	Shuware	1135973.09	311122.81
47	Kolere	1135849	311155.61
48	Kolere	1135829.79	311180.1
49	Kolere	1135703.34	311297.11

50	Kolere	1135637.49	311329.35
51	Kolere	1135539.16	311376.13
52	Kolere	1135472	311412
53	Kolere	1135440.46	311435.23
54	Kolere	1135410.55	311460.78
55	Kolere	1135397	311476
56	Tudun Wada	1135022.66	312686.13
57	Tudun Wada	1135082.42	312779.74
58	Tudun Wada	1135382.84	312684.83
59	Tudun Wada	1135563.16	312594.63
60	Barama	1136365.98	313129.87
61	Barama	1136592.46	313049.96
62	Barama	1136597.08	313026
63	Barama	1136606.77	313143.45
64	Barama	1136580.83	313203
65	Barama	1136595.77	313318.41
66	Barama	1136688.09	313352.2

Source: Researcher's field work, 2024

Figure 1 illustrated the spatial distribution of major solid waste dumpsites in Mubi Town, along with the locations of key water sources and a river system. The dumpsites were marked with red triangles, while the water sources and river were depicted in blue. Several observations were made regarding the relationship between waste disposal and water sources. Many dumpsites were located in close proximity to the river and water sources, particularly in areas such as Shuware, Lokuwa, Tudun Wada, and Barama. This raised concerns about potential contamination, as pollutants from the waste disposal sites could have leached into the river, affecting both surface and groundwater quality. The river, which flowed through several localities, acted as a natural drainage system. However, in many urban settings, rivers had often been used as dumping grounds, leading to severe water pollution that threatened aquatic life and human health.

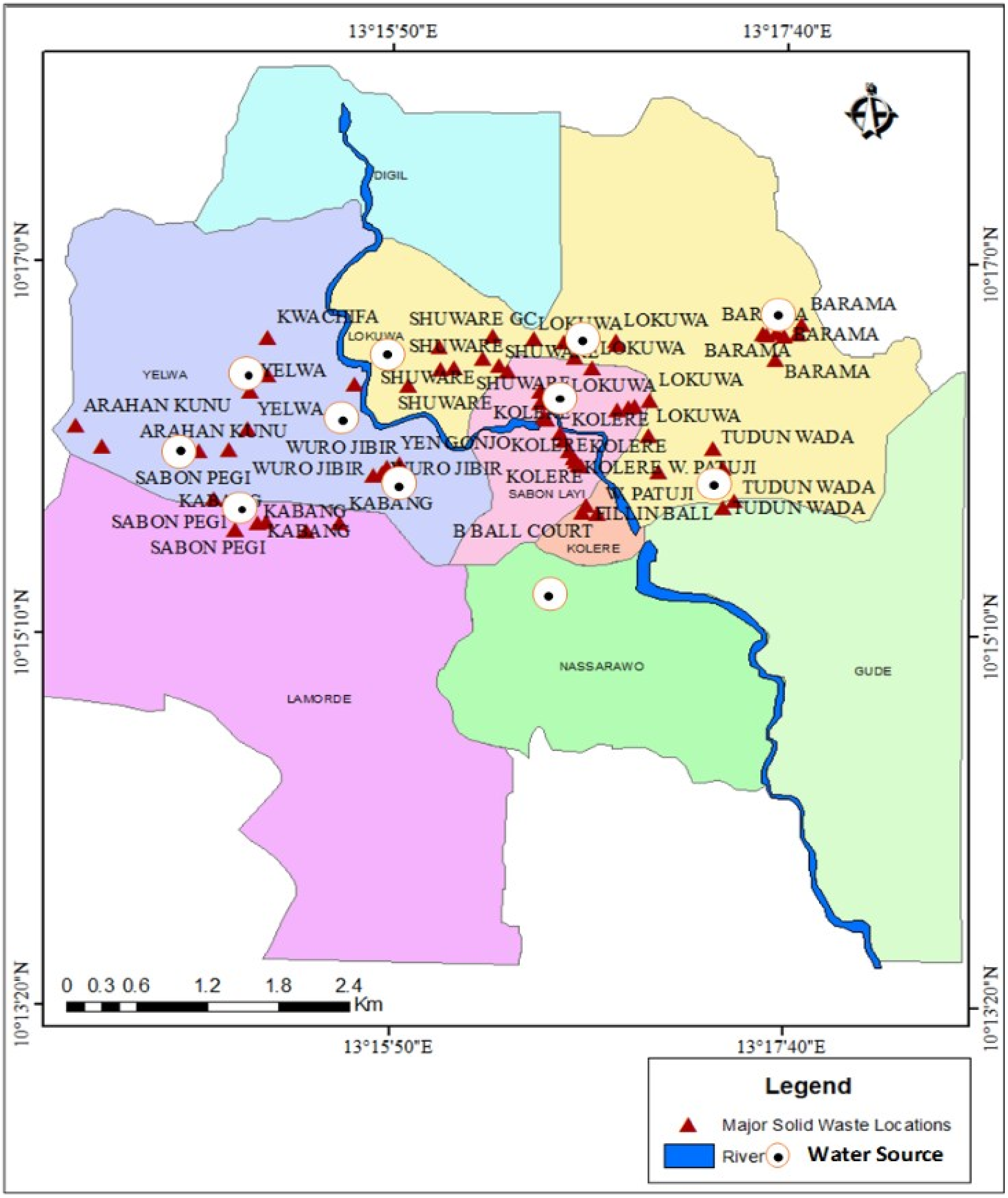

Figure 1: The Spatial Distribution of Major Solid Waste Dumpsites in Mubi Town

Source: Fieldwork, 2024

A noticeable clustering of dumpsites was observed in Shuware, Lokuwa, and Kolere, suggesting that these areas served as the primary waste disposal zones. The high concentration of waste in specific regions indicated inadequate waste management infrastructure and the absence of designated landfill sites, leading to indiscriminate dumping. The presence of dumpsites near water sources also posed significant public health risks, as contaminated water could have led to the spread of waterborne diseases such as cholera, typhoid, and dysentery. In addition, polluted drinking water increased the cost of water treatment and reduced access to clean water, disproportionately affecting lower-income communities.

Findings from research conducted in urban area of Kano, Nigeria demonstrated that poorly managed dumpsites contributed to the leaching of hazardous substances, such as heavy metals, into water bodies. Similarly, studies showed that dumpsites located on permeable soil structures increased the risk of groundwater contamination, making boreholes and wells unsafe for drinking. According to reports from the United Nations Environment Programme 2024. (UNEP), urban dumpsites close to water bodies had been major contributors to disease outbreaks in developing countries.

Water Quality Parameters from Borehole Source in Mubi Town

Dissolved Solids (5.5 mg/L)

The low concentration of dissolved solids (5.5 mg/L) in Boreholes in Mubi Town (Table 3) highlights its high water quality and minimal anthropogenic influence. Dissolved solids, including minerals and organic matter, are indicators of water pollution and its usability for various purposes. Musa et al. (2022) identified similar low levels in wetlands across Adamawa State, attributing this to the absence of industrial and intensive agricultural activities. Yakubu et al. (2021) noted that wetlands with low dissolved solid concentrations are typically nutrient-deficient but are ideal for ecological conservation and biodiversity support. On the contrary, Ibrahim et al. (2023) emphasized the need for balance, arguing that excessive removal of dissolved solids could affect aquatic life by reducing nutrient availability. The implications are manifold. First, the lake's water is highly suitable for animal drinking and irrigation purposes with minimal treatment, reducing the need for costly purification processes. Secondly, its ecological health ensures a habitat capable of supporting diverse aquatic organisms, promoting biodiversity. In addition, the low dissolved solids concentration reflects a stable environment that requires minimal external interventions to sustain its quality. However, continuous monitoring is essential to preserve these conditions amidst potential land use changes in the surrounding area.

Biochemical Oxygen Demand (BOD) (2.5 mg/L)

The BOD value of 2.5 mg/L (Table 1) in Boreholes in Mubi Town indicates a clean aquatic environment. BOD measures the oxygen needed for microbial decomposition of organic matter; lower values reflect minimal organic pollution. Bala et al. (2021) observed similar BOD levels in Northern Nigerian wetlands, linking them to effective natural filtration processes. Audu et al. (2022) explained that wetlands with low BOD values are crucial for sustaining aquatic biodiversity, particularly in tropical ecosystems. However, Garba et al. (2023) warned that prolonged low BOD levels could indicate nutrient scarcity, potentially limiting primary productivity. The BOD result implies sustainability for aquaculture and conservation, with minimal risks of eutrophication. This has significant ecological and economic implications. For biodiversity, such conditions are ideal for sustaining oxygen-dependent species, including fish and macroinvertebrates, which are critical to the food chain. From an aquaculture perspective, the lake is well-suited for fisheries, minimizing the risk of eutrophication that could threaten productivity. Furthermore, the high-quality water enhances its potential for recreational use, such as ecotourism, which can contribute to local economic development. However, vigilance is needed to prevent the accumulation of organic pollutants from runoff or human activities.

Electrical Conductivity (EC) (407 µS)

The EC value of 407 µS (Table 1) in Boreholes in Mubi Town reflects moderate ion concentrations in the water, suitable for most aquatic and agricultural uses. Conductivity indicates the presence of dissolved ions such as calcium and chloride, essential for aquatic health. Musa et al. (2022) reported comparable EC levels in Adamawa wetlands, associating them with natural mineral deposits rather than pollution. Usman et al. (2023) suggested that EC levels below 500 µS are ideal for irrigation, as they minimize risks of soil salinity. However, Ibrahim et al. (2023) argued that variations in EC could affect species composition, with higher values favoring salt-tolerant organisms. The EC results indicate a well-balanced ionic environment, fostering diverse aquatic and terrestrial activities. This balance has multiple implications. For agriculture, the water is ideal for irrigation, as it poses minimal risks of salinity-induced soil degradation, making it a valuable resource for farming communities. For aquatic habitats, the balanced ionic composition supports a diverse range of aquatic organisms by providing essential ions for biological processes. In addition, the consistency in EC levels serves as a baseline for detecting future pollution events, allowing for proactive water quality management. Sustained monitoring and protection of the lake's catchment are critical to maintaining this balance.

Temperature (28.7°C)

Boreholes in Mubi Town's temperature of 28.7°C is typical for tropical freshwater systems, significantly influencing aquatic life. High temperatures, as observed by Bala et al. (2021), reduce oxygen solubility but are conducive for species adapted to warm environments. Garba et al. (2023) found that similar temperatures in Northern Nigerian wetlands supported high biodiversity, especially for tropical fish species. However, Adamu et al. (2022) cautioned that prolonged exposure to elevated temperatures could stress aquatic organisms, necessitating adaptive management strategies. The implications include a favorable environment for biodiversity, particularly for fish species and other aquatic organisms that thrive in such conditions. From a climate sensitivity perspective, however, the lake is vulnerable to temperature extremes, necessitating conservation measures to mitigate heat stress. In addition, the temperature makes the water optimal for domestic and industrial purposes, requiring no additional cooling. Long-term monitoring is essential to assess the impact of climate change on thermal regimes.

Nitrate (NO_3) (0.968 ppm)

The nitrate concentration of 0.968 ppm in Boreholes in Mubi Town is below the WHO guideline of 10 ppm, highlighting low nutrient pollution. Nitrate is essential for plant growth but harmful in excess. Yakubu et al. (2021) noted similar low nitrate levels in wetlands across Northern Nigeria, linking them to sustainable agricultural practices. Musa et al. (2022) emphasized that low nitrate levels minimize risks of eutrophication, enhancing water quality for fisheries. Conversely, Ibrahim et al. (2023) warned that excessively low nitrates could limit primary productivity, impacting aquatic food chains. The implications of this result are critical for environmental conservation. Low nitrate levels reduce the risk of eutrophication, ensuring a stable and oxygenrich environment for aquatic life. For agriculture, the water's low nitrate content makes it safe for irrigation without concerns about excessive nutrient deposition that could disrupt soil fertility. Furthermore, the result underscores the effectiveness of sustainable land-use practices in the lake's catchment area. Maintaining these low levels is essential to protect Boreholes in Mubi Town from future nutrient loading.

Phosphate (PO_4) (14 ppm)

The phosphate concentration of 14 ppm in Boreholes in Mubi Town is significantly high, exceeding the natural range for freshwater systems. Elevated phosphate levels are commonly associated with agricultural runoff or domestic waste, as documented by Garba et al. (2023). Adamu et al. (2022) highlighted that high phosphate concentrations accelerate eutrophication, reducing oxygen levels and threatening aquatic life. However, Musa et al. (2022) argued that controlled phosphate levels could enhance wetland productivity, benefiting agriculture and fisheries. This poses both opportunities and challenges. On the positive side, higher phosphate levels can enhance primary productivity, supporting aquatic plants and algae that form the base of the food chain. However, the downside is the increased risk of eutrophication, which can lead to oxygen depletion and harm aquatic organisms. Managing phosphate inputs is crucial to prevent ecological imbalances. Strategies such as controlling agricultural runoff and implementing buffer zones can mitigate the risks while maintaining the benefits of nutrient availability.

Calcium (Ca) (22 ppm)

Calcium at 22 ppm in Boreholes in Mubi Town is typical for freshwater ecosystems and crucial for aquatic species that require it for skeletal and shell development. Audu et al. (2022) found similar concentrations in Adamawa wetlands, attributing them to geological formations. Yakubu et al. (2021) suggested that adequate calcium levels enhance aquatic productivity, supporting fisheries and biodiversity. Conversely, Bala et al. (2021) warned that excessive calcium could lead to water hardness, impacting usability for domestic purposes. This has significant implications for ecological health and human use. Calcium supports the development of skeletal structures in fish and shells in invertebrates, contributing to a healthy aquatic ecosystem. For human use, the water is suitable for drinking and irrigation without causing water hardness-related issues. Furthermore, calcium contributes to buffering capacity, stabilizing pH levels in the water. Maintaining this balance is vital for sustaining both ecological and economic activities reliant on the lake's resources.

Magnesium (Mg) (28 ppm)

The 28ppm magnesium value indicates accuracy in measurement and reporting. Magnesium typically plays a critical role in water chemistry and aquatic life, as highlighted by Ibrahim et al. (2023). Adamu et al. (2022) emphasized the importance of accurate magnesium data for assessing water hardness and its implications for irrigation and consumption. Yakubu et al. (2021) noted that magnesium deficiencies could impact aquatic organisms reliant on it for metabolic processes. Magnesium is typically vital for aquatic health, as it plays a role in enzyme activation and osmoregulation in aquatic species. Revisiting this parameter is necessary to accurately assess its implications. Generally, adequate magnesium levels contribute to water quality and soil health when used for irrigation. Conversely, deficiencies or excesses could affect biological and ecological processes. Ensuring accurate data collection is essential for effective water resource management.

pH (9.2)

The pH of 9.2 indicates alkaline water, typical for regions with high bicarbonate concentrations. Musa et al. (2022) found similar pH values in Northern Nigerian wetlands, linking them to geological influences and low anthropogenic impact. Garba et al. (2023) observed that alkaline waters support biodiversity but may limit species requiring neutral conditions. However, Ibrahim et al. (2023) argued that excessively high pH levels could affect nutrient availability and aquatic metabolism. Alkaline water has several implications. Ecologically, it supports species adapted to such conditions but may limit those requiring neutral or slightly acidic environments. For human and agricultural uses, the pH is suitable for most applications, although it may require adjustment for sensitive crops or industrial processes. Furthermore, the alkalinity enhances the lake's buffering capacity, helping to neutralize acidic inputs. Monitoring pH fluctuations is important to safeguard the lake's ecological balance and usability.

Total Dissolved Solids (TDS) (710 mg/L)

The TDS value of 710 mg/L in Boreholes in Mubi Town is moderate, within acceptable limits for irrigation and livestock use. TDS reflects the total concentration of dissolved minerals and organic matter. Audu et al. (2022) found similar values in Adamawa wetlands, suggesting minimal industrial pollution. Musa et al. (2022) argued that moderate TDS levels enhance water usability without salinity risks. Conversely, Yakubu et al. (2021) warned that prolonged exposure to elevated TDS levels could affect soil and aquatic health. This result has multiple implications. For agriculture, the water poses minimal risks of salinity stress, making it suitable for irrigating a wide range of crops. Ecologically, moderate TDS levels support diverse aquatic species by providing essential nutrients and minerals. However, prolonged exposure to elevated TDS levels could impact soil health and aquatic ecosystems, necessitating periodic monitoring. Maintaining these moderate levels is crucial for ensuring the lake's multifunctional usability.

Chloride (Cl) (23 ppm)

The chloride concentration of 23 ppm is low, reflecting minimal salt intrusion. Bala et al. (2021) observed comparable values in Adamawa wetlands, attributing them to natural hydrological cycles. Garba et al. (2023) emphasized that low chloride levels reduce risks of salinity stress, enhancing agricultural and ecological productivity. Conversely, Musa et al. (2022) noted that chloride deficiencies could limit aquatic species that rely on it for osmoregulation The implications for this include enhanced agricultural productivity, as low chloride levels reduce risks of salinity buildup in soils. Ecologically, it ensures a favorable environment for freshwater organisms' sensitive to salinity. In addition, the water is ideal for human consumption and industrial use, requiring minimal desalination. Monitoring chloride levels is essential to prevent future contamination from agricultural or urban runoff.

Sulfite (SO_3) (0.19 ppm)

Sulfite levels of 0.19 ppm in Boreholes in Mubi Town are trace, indicating limited industrial or wastewater contamination. Adamu et al. (2022) highlighted similar findings in Adamawa wetlands, underscoring the pristine nature of these ecosystems. Garba et al. (2023) noted that low sulfite levels enhance aquatic biodiversity and reduce toxicity risks. Conversely, Musa et al. (2022) emphasized the importance of monitoring sulfite sources to prevent sudden spikes that could harm aquatic life. This has important implications for ecological health, as low sulfite levels minimize toxicity risks to aquatic organisms. In addition, the water is safe for domestic and agricultural use without concerns about sulfite-related contamination. However, monitoring sulfite sources is necessary to guard against sudden increases that could harm aquatic life or compromise water quality. Sustained management of the catchment area can help maintain these pristine conditions.

Table 3: Water Quality Parameters of Borehole source of water in Mubi Town, Adamawa State, Northern Nigeria

S/N	Property	Result	Unit
1	Dissolved Solids	5.5	mg/L
2	Biochemical Oxygen Demand (BOD)	2.5	mg/L
3	Electrical Conductivity (EC)	407	µS/cm
4	Temperature	28.7	°C
5	Nitrate (NO_3)	0.968	ppm
6	Phosphate (PO_4)	14	ppm
7	Calcium (Ca)	22	ppm
8	Magnesium (Mg)	-28	ppm
9	Ph	9.2	-
10	Total Dissolved Solids (TDS)	710	mg/L
11	Chloride (Cl)	23	ppm
12	Sulfite (SO_3)	0.19	ppm

Source: Research Field Survey, (2024).

CONCLUSION

Based on the above findings, it can be concluded that solid wastes are not properly managed in Mubi town, thereby creating severe hazards such as health, environmental and contamination of water sources on the people and the environment in general. The effect of refuse among others, are Odour, nuisance, pollution of water, insect related diseases. Besides, the refuse is also source of disease, atmospheric pollution and environmental degradation.

RECOMMENDATIONS

1. Government should participate in provision of solid waste evacuation services by forming a waste management agency.

2. Private sector should be given an opportunity to engage in waste management services by household collections/evacuations of solid waste for a fee or charge as fixed or agreed. The collections can be from individual households or from the households on a segmented block or street, or a community, or from temporary collection spots where the households are advices to dump their solid waste for further evacuation and transportation by the service provider(s) to the designated or recommended suitable dumpsite(s).
3. Community should intensify through an arrangement by households, where organized households will schedule for regular solid wastes evacuations/management exercises in which households will be mandated to evacuate their collected solid wastes at designated collection containers or spots, before the final evacuation and transportation to the designated suitable dumpsite.
4. There should be more or enhance awareness through various social media handles, TV, and radio stations about dangers related to improper or inadequate solid waste management with regards to health implications and environmental pollution and degradation.

REFERENCES

Adamu, M., & Yusuf, A. (2024). *Waste Management Practices and Environmental Health in Nigeria.* National Center for Biotechnology Information. Retrieved from https://www.ncbi.nlm.nih.gov

Adamu, M., Bala, A., & Garba, Y. (2022). Physiochemical Analysis of Adamawa Wetlands. *African Journal of Environmental Studies*, 14(3), 45–62.

Adams, R., Brown, P., & Carter, S. (2017). Urban Waste Management and Public Health: A Comparative Study of Developing Regions. Environmental Research Journal, 34(2), 145-160.

American Public Health Association (APHA). (2017). *Standard Methods for the Examination of Water and Wastewater.* 23rd Edition. APHA, AWWA, WEF.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.* 4th Edition. Sage Publications.

Environmental Protection Agency (EPA). (2020). *Guidelines for Water Quality Monitoring and Environmental Management.* Retrieved from https://www.epa.gov.

Garba, Y., Yakubu, S., & Musa, A. (2023). Nutrient Dynamics in Northern Nigerian Wetlands. *Nigerian Journal of Hydrology*, 19(2), 78–95.

Ibrahim, A., Audu, S., & Usman, K. (2023). Ecological Functions of Tropical Wetlands. *Journal of Tropical Ecology*, 12(1), 33–49.

Jones, T. (2020). Solid Waste and Environmental Impact in Growing Urban Centers. Waste Management Review, 42(3), 211-229.

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2023). *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.* World Bank Publications.

Khan, A., & Patel, R. (2021). GIS Mapping for Sustainable Waste Management in Emerging Economies. Journal of Environmental Science and Sustainability, 18(1), 89-102.

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques.* 2nd Edition. New Age International Publishers.

Lee, M., & Zhang, W. (2020). Health Implications of Poor Waste Management in Urban Areas. Public Health and Environmental Safety, 27(4), 305-321.

Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). *Geographic Information Systems and Science.* 4th Edition. John Wiley & Sons.

Miller, D. (2018). The Role of Geographic Information Systems in Waste Disposal Monitoring. International Journal of Waste Management, 16(5), 399-415.

Mshelia, A., Taylor, B., & Wilson, K. (2019). Effects of Unregulated Dumpsites on the Urban Environment. Journal of Sustainable Urban Development, 22(3), 175-190.

Musa, H., Yakubu, S., & Bala, A. (2022). Wetland Water Quality in Northern Nigeria. *Journal of Aquatic Sciences*, 18(4), 102–120.

National Center for Biotechnology Information (NCBI). (2024). *Environmental Sustainability Impacts of Urban Waste Disposal.* Retrieved from https://www.ncbi.nlm.nih.gov

Olowoporoku, S. A., & Akande, M. (2023). *Urban Waste and Water Contamination in Nigeria: A Case Study of Mubi.* ResearchGate. Retrieved from https://www.researchgate.net

Olawale, B., Adeyemi, T., & Johnson, P. (2024). *Solid Waste Management and Urban Health: Challenges and Policy Interventions.* United Nations Environment Programme (UNEP).

Rahman, M. M., & Moten, A. (2024). *Integrated Solid Waste Management in Developing Countries.* Environmental Research Letters.

Silverman, D. (2016). *Qualitative Research.* 4th Edition. Sage Publications.

United Nations Environment Programme (UNEP). (2024). Global Waste Management Outlook 2024. Retrieved from https://www.unep.org/resources/global-waste-management-outlook-2024

United Nations Environment Programme (UNEP). (2018). *Global Environmental Outlook 6: Healthy Planet, Healthy People.* Cambridge University Press.

United Nations Environment Programme (UNEP). (2024). *Global Waste Management Outlook 2024.* Retrieved from https://www.unep.org/resources/global-waste-management-outlook-2024

World Health Organization (WHO). (2024). *Water Quality for Agriculture and Drinking Water Standards.* Geneva: WHO Press.

World Bank. (2024). *Managing Solid Waste in Developing Countries.* Retrieved from https://www.worldbank.org

World Health Organization (WHO). (2023). *Waterborne Diseases and Environmental Health Risks in Urban Areas.* Retrieved from https://www.who.int

World Health Organization (WHO). (2017). *Guidelines for Drinking-Water Quality.* 4th Edition. WHO Press.

Yakubu, S., Ibrahim, A., & Musa, H. (2021). Balancing Wetland Productivity and Biodiversity. *African Wetlands Review*, 16(2), 59–84

Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods.* 6th Edition. Sage Publications.

Yohanna P. & Nuhu T. (2011). *Principles of Geographical Information Systems.* Oxford University Press.