Solid Waste Management, Surface Water Quality and River Basin Contamination in Akwa Ibom State: Case Study of Ikpa River Catchment

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Abstract

Solid waste management is one of the problems confronting many developing countries of the world. Recent events in major urban centres have shown that the problem of waste management has become too complex to handle and beyond the capacity of city authorities, federal governments, State and professionals agencies. The study therefore examines solid waste management, river basin contamination and surface water quality and river basin in Ikpa River Basin Catchment, Akwa Ibom State aimed at examining the variability in the Physico-chemical parameters at different sections of the stream channel, examine and compare the difference in the quality of sampled surface water with World Health Organization and Nigeria Standard for Drinking Water Quality as well as assess the impacts of waste disposal on health status of residents in the area. Laboratory analytical method and survey techniques were adopted closer to the dumpsite and decreases with distance away from the dumpsite. Hence, the result indicates that there is a significant variability in the physico-chemical parameters at different segments of the stream channel. More so, with some of the physico-chemical properties (colour, Phosphate, Calcium and Magnesium. More so, Nickel and Cadmium) exceeding WHO limits, the study shows that the concentration of the physio-chemical properties of the stream is deeply affected by the dumpsite. Findings from the study also indicates the negative impact of waste dump on surface water quality to include pollution of drinking water, loss of aesthetic value, spread of waterborne diseases, destruction of aquatic flora and fauna, threat to economic life of the people and siltation of the stream. As a result of this waste dump, the river eacosystem is under serious threat because of a break-in the food chain causing declining fish stocks, death of aquatic life, and destruction of aquatic flora and fauna. Furthermore, unsanitary conditions and water pollution due to the waste dump make the situation so dire that waterborne diseases are now widespread. It was recommended that there is need for government to relocate the dumpsite to another location to safe the water from disappearance and pollution or governments should ban or discourage indiscriminate disposal of wastes within stream environments. Moreover, there is need for public awareness and enlightenment programmes on the need for effective and efficient wastes disposal within stream environments. This is achievable through workshop/seminar, radio and television programmes, among others.

Keywords: *Solid Waste Management, Surface Water Quality, River Basin Contamination, Ikpa River Catchment, Akwa Ibom State*

Introduction

The management of solid waste remains a complex issue throughout the world especially in developing countries (Lazola, Hlekani, Oseni, Motebang, Nakin and Zendy 2023). Solid waste management is a significant environmental challenge worldwide, affecting both developed and developing nations. The rapid increase in urbanization and industrialization has led to the generation of large amounts of solid waste, posing a serious threat to surface water quality globally (Hoornweg and Bhada-Tata, 2012). Poor solid waste management practices, including inadequate collection, disposal, and treatment, have resulted in the pollution of water bodies with heavy metals, organic pollutants, and pathogens, threatening ecosystems and human health (Troschinetz and Mihelcic, 2009). According to the World Bank, global solid waste generation is expected to rise from 2.01 billion tonnes in 2016 to 3.40 billion tonnes by 2050, which will further exacerbate water quality issues (Kaza *et al.,* 2018).

Waste is known to pollute water bodies, particularly when waste from urban centres is deposited in river catchments. Overland flow draining through solid wastes are channeled through urban drainage systems into river basins. The leachates could step through porous soils and pollute the underlying aquifer and finally into stream channels. Paved urban surfaces also permit leachates to flow into depressions and river basins. This means that the characteristics of waste leachates could be reflected in surface water characteristics of nearby river basins.

In Africa, the challenge of solid waste management is compounded by rapid urbanization, poverty, and lack of infrastructure. Many African countries, including Nigeria, face severe problems related to the disposal of solid waste, which often ends up in water bodies due to poor management practices (Abarca-Guerrero *et al.,* 2013). In sub-Saharan Africa, only about 44% of solid waste is collected, and a significant portion of that is disposed of in open dumps, leading to contamination of surface water sources (Kaza *et al.*, 2018). The impact of waste mismanagement on surface water quality is evident in many African cities where rivers and lakes are polluted with leachates, plastics, and other hazardous waste materials. Consequently, solid waste management is one of the many problems confronting many developing countries and recent events in major urban centres have shown that the problem of waste management has become too complex to handle and has seen dwindling efforts of city authorities, federal governments, state and professionals alike in addressing the issue.

The supply of drinking water worldwide is derived from one-third of the total surface water sources such as rivers, dams, lakes, and canals (Edokpayi, Odiyo and Durowoju 2017). Surface water presents an important source of freshwater; however, the volume of water available to all life from these surface water bodies is constantly declining. This is because of a variety of factors, including anthropogenic activities and the greenhouse effect (Nwaneri, Nwachukwu, Ihua and Nwankwo 2018). Further assessment revealed that the quality of freshwater from water bodies reduces due to due to various pollutants as a result of human activities such as washing, bathing, and irrigation disposal along the river channel. This illegal waste dumping on riverbanks endangers the habitats of the creatures residing there (Meride and Ayenew 2016).

One of the prominent components of man's environment is river/stream that flows gently within its natural course. It serves as the source of water that man drinks. Other purposes such as agricultural and domestic are also servicing by water from the river/stream. Stream provides both defense and transportation mean for human beings, yet when the volume of water in it smells due to disposal of indecent elements such as waste it then starts to pose a threat to residents around its course. In order words, waste is seen as an unavoidable by-product of most human activities. Economic development and rising standard of living in Uyo and its environs have led to increases in the quality and complexity of generated waste; whilst the provision of expanded health-care facilities have added substantial qualities of hazardous waste and biomedical waste into the waste stream with potentially severe environmental and human health consequences.

Findings by Yustiani, Nurkanti, Suliasih and Novantri (2018) indicates that unregulated growth of urban areas and inadequate infrastructural facilities for collection, transporting, treating and disposal of waste have all contributed to increase in pollution. Furthermore, the heterogeneous mixture of plastics, cloths, metals and organic solution which are inevitable products of production and consumption are on increase as a result of urbanization that give room for indiscriminate discharge of solid and sewage waste into river channels thereby causing serious flooding which is a treat to life in general. Similarly, wastes of different types, mostly solid wastes are the major input of dumpsites/landfills. Groundwater flows from areas of higher topography towards areas of lower topography, in the course of this degradable materials in dumpsites which form leachate flow in that wise and contaminate the groundwater of the study area.

Dumpsite practice is the disposal of solid wastes by infilling depressions on land. The depressions into which solid wastes are often dumped include valleys (abandoned) sites of quarries, excavations, or sometimes a selected portion within the residential and commercial areas in many urban settlements where the capacity to collect, process, dispose of, or re-use solid waste in a cost-efficient, safe manner is often limited. The practice of dumpsite system as a method of waste disposal in many developing countries is usually far from standard recommendations (Magaji and Oluyori, 2021). A standardized landfill system involves carefully selected location, and is usually constructed and maintained by means of engineering techniques, ensuring minimized pollution of air, water and soil and risks to man and animals. It involves placing waste in lined pit or a mound (Sanitary landfills) with appropriate means of leachate and landfill gas control (Eludoyin and Oyeku 2010).

In Akwa Ibom State, the Ikpa River Basin is a vital water resource for communities, providing water for domestic, agricultural, and industrial purposes. However, the quality of water in the Ikpa River has been compromised by the indiscriminate dumping of solid waste, which has become a critical environmental issue in the region (Udoh and Ekanem, 2016). The lack of proper waste management infrastructure, coupled with poor public awareness and enforcement of environmental regulations, has led to the contamination of the river with pollutants such as heavy metals, plastics, and organic waste. This pollution not only affects water quality but also poses risks to public health, aquatic life, and livelihoods dependent on the river

The dumpsites contain domestic wastes, vegetable wastes, waste papers; scrap metals, cans for different chemicals, plastic containers, old rags, vehicle tyres, scalpels and human wastes.

Some of these wastes are hazardous and are bound to cause serious health problems if they enter domestic water supply. Leachate from dumpsites varies widely in composition depending on many interacting factors such as the composition and depth of waste, availability of moisture and oxygen, landfill design, operation and age. When precipitation finds its way into a landfill, it causes the extraction of water-soluble compounds from the decomposed wastes thus forming garbage juice commonly called the leachate (Salami and Susu 2019). Hence, it is on this background that the current research seeks to examines solid waste management and surface water quality in Ikpa River Basin Catchment, Akwa Ibom State.

Ineffective waste management practices lead to the contamination of water bodies with various pollutants, including plastics, heavy metals, and organic waste, which pose significant risks to ecosystems and human health (UNEP, 2015). Despite international efforts to promote sustainable waste management and protect water resources, many countries still struggle with inadequate infrastructure, financial constraints, and lack of enforcement of environmental regulations (Kaza *et al.*, 2018).

In Asia and Africa, the rapid growth of urban areas has outpaced the development of adequate waste management systems, resulting in severe pollution of rivers and lakes. In many Asian and African countries, waste collection services are insufficient, and open dumping is common, leading to the degradation of water quality in surface water bodies (Salami and Susu 2019). The lack of public awareness and engagement in waste management, combined with weak regulatory frameworks, exacerbates the problem, threatening water security and public health.

Waste from agriculture and industries can also cause serious health inks. Other than this, co-disposal of industrial hazardous waste with municipal waste can expose people to chemical and radioactive hazards uncollected solid wastes can also obstruct storm waste turnoff resulting in the forming of stagnant water bodies that become the breeding ground of disease waste dump near a water source also cause contamination of the water body or ground-water source. Direct dumping of untreated waste in streams, rivers, seas and lakes results in the accumulation of toxic substances in the food chain through plants and animals that feed on it.

In most of the developing countries, solid wastes are being dumped on land without adopting any acceptable sanitary landfilling practices. Solid wastes disposed on land mixes with the liquids already trapped in the services of the wastes and leach compounds from the solid waste drain into the river basin. Given that surface sources provide around one-third of the world's drinking water needs, their contamination worsens the issue and access to clean drinking water (Lazola *et al.*, 2023). The leachate contains dissolved inorganic and organic solutes which in the course of time, the leachate containing elements like magnesium, ammonia, calcium, potassium, nitrogen, trace metals (iron, copper, manganese, chromium, nickel, lead and others.) and organic compounds like phenols, polyaromatic hydrocarbons, acetone, benezene, toluene, cholorform among others. gets concentrated and migrate into the ground water aquifer media and further pollute or contaminate groundwater supply. Areas near the dumpsite have a greater possibility of groundwater contamination because of the potential pollution source of leachate originating from the dumpsite. Such contamination of groundwater results in a substantial risk to local groundwater resources and users and to the natural environment.

In the major cities of Nigeria for instance, the problem of solid waste management has been characterized by single and ad hoc solutions such as mobilizing people to collect waste and de-silt choked gutters after a flood disaster or for an occasion, temporal allocation of waste contracts and dumping or building a central solid waste composting site. However, it is a common site seeing water bodies flowing through most of these solid waste dump sites and polluting nearby streams. The design and optimization of solid waste management technologies and practices that aim at maximizing the yield of valuable products from waste as well as minimizing the environmental effects have little or no consideration in developing countries.

All water pollutants are hazardous to humans as well as lesser species. For example, sodium is known to cause cardiovascular disease while nitrates are involved in blood disorders. Mercury and lead are also widely known to cause nervous disorders. Some other contaminants are carcinogens while others are known to be toxic to humans and can also alter chromosomes. Others causes liver and nerve dam- age, skin eruptions, vomiting, fever, diarrhea, and fetal abnormalities. These known effects therefore support the need to assess the effects of these dumpsites on the water quality of these water resources which are widely in use by the communities leaving around them.

The present situation of a stream along the waste dumpsite in Uyo village road in Uyo Local Government Area of Akwa Ibom State and in several parts of Nigeria portrays the above-described situation. Hence, the need for adequate and efficient waste disposal system in the research/study area cannot be over emphasized. Adequate and efficient waste disposal system is required for good health and neat environment. The effects of waste disposal and management has attracted the attention of various researchers whose studies were limited to waste management and effects of waste on underground water, on health status and visual intrusion. Waste disposed or flushed into the drainages and streams engender major environmental problem, particularly, in the host communities. In the case of Uyo waste dumpsite, the bulk of waste generated within Uyo metropolis are dumped into river courses which has led to a number of waste accumulation along the river courses and drainages resulting to water pollution, drainage blockage, infrastructural degradation, land pollution, flooding, erosion, leaching of pollutants into streams as well as spread of diseases like cholera, diarrhea, typhoid fever which are water-borne.

Nigeria, including Akwa Ibom State, faces a critical waste management crisis, with significant implications for surface water quality. In the Ikpa River Basin catchment area, the problem of solid waste mismanagement is pronounced, leading to the pollution of the river with hazardous substances that endanger aquatic life and the health of local communities (Akpan and Akan, 2013). Despite policies aimed at improving waste management, the implementation has been ineffective due to factors such as limited funding, lack of infrastructure, and weak enforcement of environmental laws. In Akwa Ibom State, the situation is further compounded by rapid urbanization, poor waste management practices, and limited public awareness, making the Ikpa River highly susceptible to pollution from solid waste. It therefore become crucial to examines solid waste management and surface water quality in Ikpa River Basin Catchment, Akwa Ibom State.

Objectives of the Study

The aim of the research is to examines solid waste management, surface water quality and river basin contamination in Ikpa River Basin Catchment, Akwa Ibom State. The specific objectives are: To

1) Examine the management and characteristics of solid waste in Ikpa River basin
2) Analyze the physico-chemical characteristics of leachates and control samples from the wastes
3) Examine the variation among the physico-chemical parameters of surface water.
4) Examine and compare the difference in the quality of sampled surface water and leachates with World Health Organization and Nigeria Standard for Drinking Water Quality.
5) Assess the impact of waste disposal on water quality in Ikpa River basin.

Study Area

The Ikpa River Basin is located between longitude 7°46’ 34.9’’ and 8°3’ 11.9’’, East of Greenwich Meridian and latitudes 5°0’ 3.801’’ and 5°16’ 49.129’’, North of the Equator (Figure 1.1). The dumpsite is located along Uyo-Village Road at latitude 5° 2'47.56"N and longitude 7°56'12.04"E.

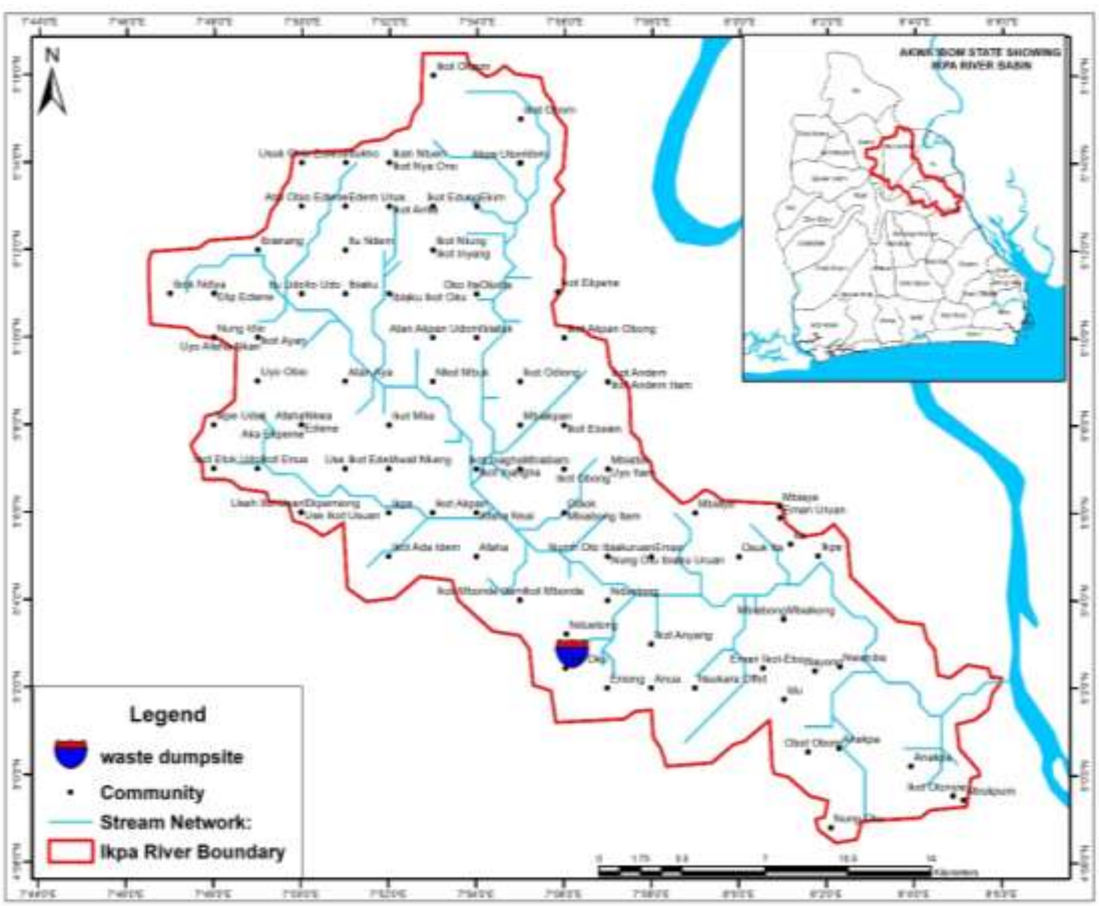

Figure 1.1: Ikpa Basin Showing Waste Dumpsite

The climate of Ikpa Basin is a tropical rainy type which experiences abundant rainfall with very high temperature. Uyo has two distinct seasons namely, wet and dry seasons, while the dry season starts from November, December, January, February and March. The wet season starts from April, June, July, September and October respectively. Specifically, the total annual rainfall in Uyo ranges between 1599 mm and 3855.9 mm with a mean annual rainfall of 2429.83mm. The mean monthly relative humidity (percent) in the study area is high during the rainy season with July through to September experiencing highest level of humidity in the year. This decreases further during the dry season months (December, January and February). The Ikpa River Basin catchment is characterized by a relatively flat to gently undulating terrain, typical of the Niger Delta region. Elevations in the area generally range from lowland areas near the river, typically about 10 to 50 meters above sea level, to slightly higher uplands that rarely exceed 100 meters.

The area features a mix of floodplains, low terraces, and levees formed by alluvial processes. The gentle slopes facilitate surface runoff into the river and its tributaries but can also lead to flooding during heavy rains due to the slow drainage of the flat terrain. Soils in the Ikpa River Basin are predominantly alluvial, sandy, and clayey in texture, supporting agriculture but prone to erosion and sedimentation, especially when vegetation cover is removed or during heavy rains.

Ikpa River basin is a tributary of the Cross River drainage system. The study area like other parts of Akwa Ibom State lies entirely on the Coastal plain of Southern Nigeria. Consequently, no part of the state constitutes an area of appreciably high relief (Usoro, 2010). In terms of drainage, the study area is a tributary of Ikpa River basin which its final destination is the Atlantic Ocean.

The Ikpa River is a significant tributary within the larger Cross River Basin system. It plays a crucial role in draining the catchment area and contributes to the hydrological dynamics of the region. The river is characterized by a meandering course with numerous bends and oxbow lakes typical of lowland river systems.

The area is drained by Ikpa River that flows from the north to the southern part of the area. The city lies within the tropical rain forest Region and within the main modified rainforest zone now called oil palm bush. Its vegetation type is typical of evergreen rain forest and mangrove. The area falls within the equatorial rain forest belt that houses vegetation of green foliage of trees and shrubs. The study area original vegetation belt is within tropical rainforest zone, but due to prolonged period of anthropogenic activities, significant vegetation cover has been removed, leaving the land with secondary forest, bush fallow and grasses (Ituen, 2006).

The main socio-economic activity in the study area is trading. This is induced by the rich soil which stretches from the northern to the southern parts of the state.

The dumpsite is located within Uyo, the capital city of Akwa Ibom State, Nigeria. The area is not spared the menace of unevacuated solid waste. The creation of Akwa Ibom State in 1987 had led to the upgrading of Uyo from a provincial and local government headquarters to a state capital. Since then, the city has experienced a great influx of people accompanied by a high demand for both residential and commercial accommodation. These have resulted in urban environmental problems of which the management of solid household waste is clearly one of the most serious environmental problems. Many areas of the city have become health risk owing to the accumulation of solid waste. A close examination of municipal solid waste management in many developing cities including Nigeria shows that the present strategies are deficient and need to be re-addressed. Rapid urbanization in the developing world, if ignored, can be a threat to health, the environment and urban productivity. Cities are known to be engines of economic growth, but the environmental implications of such growth need a proper assessment, particularly in terms of environmental quality. Over the years, the government of Akwa Ibom State had established parastatals and agencies which regulate the disposal of waste by households and they are evacuated from the waste bins and taken straight to the dumpsite on Uyo village road, Uyo, Akwa Ibom State.

In the past, communities around the Ikpa River Basin, like many rural and semi-urban areas in Nigeria, managed waste through traditional methods such as open dumping, burying, and burning. These practices were generally sustainable when populations were lower and waste generation was primarily organic and biodegradable. Waste was disposed of in nearby bushes, water bodies, or used as manure for agriculture. The environmental impact was minimal due to the lower volume of waste and the natural biodegradability of materials.

Over the years, urbanization and population growth in areas surrounding the Ikpa River Basin have increased significantly, leading to higher volumes of waste, including non-biodegradable materials like plastics, metals, and other synthetic products. The expansion of Uyo, the capital city of Akwa Ibom State, and other nearby towns has intensified the pressure on the Ikpa River Basin, resulting in increased domestic, commercial, and industrial waste generation. With limited formal waste management systems, residents and businesses often resorted to informal waste disposal methods. This included dumping waste directly into the Ikpa River, on riverbanks, and in unauthorized dumpsites around the catchment area. Informal waste pickers and scavengers became common, sorting through dumps for recyclable materials. However, this did little to mitigate the environmental and health impacts of improper waste disposal.

The increasing volume of waste, particularly plastics and hazardous materials, has led to significant environmental degradation in the Ikpa River Basin. This includes water pollution, blockages of drainage channels, and the proliferation of pests and diseases.

Contaminants from solid waste, including heavy metals and organic pollutants, have impacted surface water quality, making the water unsafe for drinking, fishing, and other uses. This has directly affected the health status of residents, contributing to the prevalence of waterborne diseases, respiratory issues, and other health problems.

Materials and Method

This study adopted a cross-sectional survey design. This approach includes the collection of waste and water sample from the Ikpa River stream to the laboratory for physicochemical analysis as well as cross-sectional survey design for questionnaire administration for residents of the project area.

In mapping out the study area, the database was acquired from the office of the surveyor general of Akwa Ibom State. Data on the physico-chemical properties of the surface water was gathered from laboratory analysis of water samples that were collected from the stream. Similarly, data on World Health Organization and Nigeria Standard for Drinking Water Quality water standard was collected from WHO database. Other data based on the objectives of the study were collected through questionnaire administration and In-depth Interview with residents of the communities.

A buffer of 1km radius from the dumpsite was used for the sampling. This is to ensure that areas at the receiving end of the pollution was captured. Water sample were collected at thedumpsite and at interval of 150m from the dumpsite and the control. Using this yardstick, a total of 6 points were sampled and one control located more than 3.5km from the dumpsite was added. Surface water samples were collected with the aid of a distilled 10ml bottle water and the range of sampling were within the stream channel to the dumpsites sampled. In the questionnaire administration, simple random sampling technique was adopted in selecting the sampled population using the sampled population of the project community.

The grab and composite sampling methods (Rao, 2004 and Metcalf, 2003) were used in collecting water samples from the surface water at various locations. One-liter, transparent plastic bottles, labeled according to locations, were used in collecting the samples for physical and some chemical parameters analyses. The bottles were placed in a cooler box, to prevent them from being disturbed, and transferred to the laboratories for further analysis. On the other hand, samples were preserved during storage before laboratory analysis as recommended by Ademoroti, (1996).

Bill Godden (2004) formula for finite population was adopted in determining sample size which was 384 in total.

Samples of water collected were analyzed at the laboratory of Akwa Ibom State Ministry of Science and Technology, Obio Imo, Uyo for physical and chemical properties of surface water. The chemical parameters concentrations of the water samples were assessed using standard methods described by APHA, *et al.*, (1992) and Ademoroti, (1996).

Ten samples of waste which included over landfilled from the Ikpa River basin area were obtained and characterized for their physical composition as garbage, metal and plastics. Plastic containers of four (4) litres volume were used to obtain waste from the location. The waste was weighed, selected, reweight and the percentage of each characteristic determined. Leachates were also obtained from each sample by passing 50cl of water through the waste. The leachates were collected, bagged into two samples and analyzed in the laboratory.

The analysis was carried out to assess the physical, chemical and heavy metal concentration in surface water along waste dumpsite in Ikpa basin. The physical parameters include pH, temperature, colour, turbidity, electrical conductivity, salinity, total dissolved solids, total suspended solid and total hardness. Chemical properties analyzed include: nitrate, sulphate, phosphate, calcium, magnesium, potassium, copper, iron and zinc while the heavy metals include: zinc, manganese, chromium, nickel, cadmium and lead.

After wet acid digestion, Atomic Absorption Spectrometer (UNICAM Model) was used in the determination of concentration of metals in all the samples. Determination of Cu, Zn and Pb were carried out by direct aspiration of the water samples into an air acetylene flame. In determining the concentration of any metal in the samples, a calibration curve of the metal was prepared using aliquots from the standard stock solution of the metal or salt of the metals in preparing the working standards. From the calibration curves, the concentration of the metal in the sample was determined.

The obtained data was subjected to descriptive statistical analysis such as mean, standard deviation, coefficient of variation, graph, table, range as well as inferential statistics

Results and Discussions

Table 4.1 Total Number of Administered Questionnaire

Number of administered questionnaires	Number of retrieved questionnaires	Percentage of returned questionnaire
384	380	99

Source: Researcher's Field Work (2023).

In the survey, 384 questionnaires were administered out of which 380 were successfully retrieved at a returned rate of 99%. The demographic details of the respondents are presented in Table 4.1

Gender of Respondents

Table 4.2: Gender of Respondents

Gender	**Number of Respondents**	**Percentage (%)**
Male	221	58.16
Female	159	41.84
Total	380	100

Source: Researcher's Field Work (2023).

Table 4.2 shows the demographic data of respondents. Pertaining to sex, the table explained that 229 respondents (57.3%) were male while 159 respondents (42.7%) were female. This shows that the number of male respondents was greater than the female respondents.

4.1.1 Examine the Management and Characteristics of Solid Waste in Ikpa River Basin

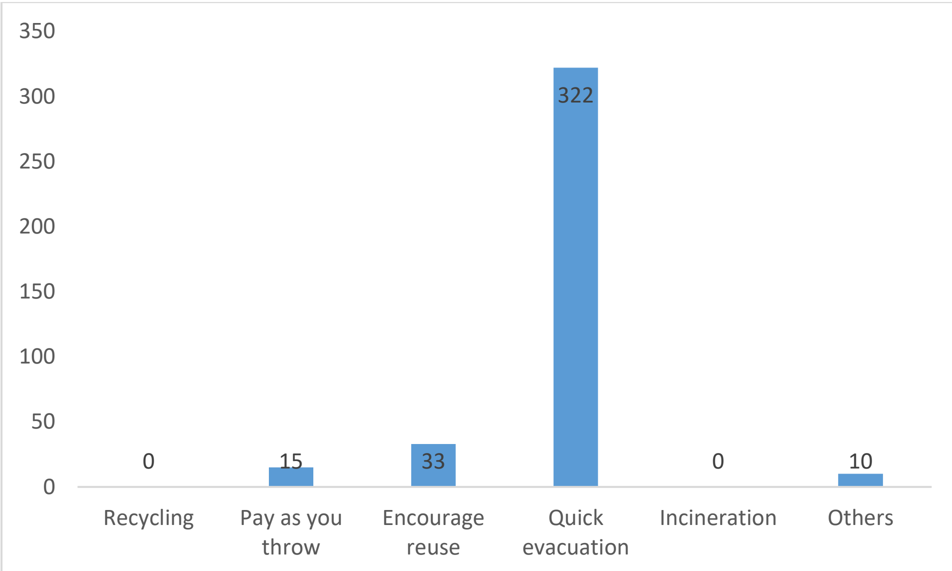

Figure 4.1: Waste Management Strategies in the Study Area

Figure 4.1 shows that within Ikpa River Basin, waste management strategies are very poor (see plate 1). Respondents only rely on quick evacuation of waste from their neighbourhood.

Plate 1: Waste Degraded Environment at Uyo Village Road

The second most adopted strategy is encouraged reuse and pay as you throw. Recycling and incineration are completely 0% in the study area which shows the poor extents of waste management in the study area. Consequently, it can be concluded that the extent of solid waste management in the study area is very poor.

Plate 1: Water sample collection

Plate 2: Stakeholders engagement

Stakeholders engagement at the study area was relevant to understand the management practices put in place in ensuring environmental quality (see plate 2 & 3).

Table 4.3: Waste Composition within Ikpa Basin

SN	Waste Structure	Percentage (%)
1	Hazardous waste	8.88
2	Wood	14.23
3	Metal	9.47
4	Textile	7.89
5	Glass	3.34
6	Inert	1.32
7	Paper	17.29
8	Plastics	13.53
9	Biodegradable	21.16
10	Other	2.89
	Total Composition	100

Table 4.3 shows that waste deposited consist mainly of 21.1% biodegradable, followed by paper waste which constitute 17.3%, wood (14.23%), plastics (13.5%), metal (9.47%), textile (7.89%), among others. This shows that the main waste generated in Ikpa River basin contain mainly biodegradable products followed by wood and plastics.

Table 4.4: Rating the Status of Waste Management in Ikpa Basin

Rate	Number of Respondents	% Response
Excellent	12	3.16
Good	32	8.42
Fair	61	16.05
Poor	231	60.79
Very Poor	44	11.58
TOTAL	380	100

Table 4.4 shows that residents of Ikpa basin rated the extent of waste management in the area as being very poor. Not less than 60% of the respondents affirmed that the extent of waste management in the area is poor. Only 16% rated tit as fair while only 3% suggest it is excellent. This gives an indication that the extent of waste management in the study area is very poor. This was also confirmed during data gathering that major sections of Uyo-Village Road and the stream is polluted due to waste dump and this raises concern for residents and commuters.

4.1.2 Analyze the Physico-Chemical Characteristics of Leachates and Control Samples from the Wastes

Table 4.1.2 gives a summary of both physical and chemical properties parameters that were considered relevant to this study. As captured in Table 4.5, all the physical parameters were observed to be below limits except colour which was observed to be higher than NSDWQ and WHO limits. This corresponds to physical observation during data gathering which was observed that the water now has yellowish colour due to the impact of waste dump along the river channel. Under chemical properties, acidic parameters (nitrate, sulphate and phosphate) were below limit. Calcium, Copper, Iron and Zinc were observed to exceed WHO and NSDWQ limits. In the heavy metal concentration, Manganese, Chromium, Nickel, Cadmium and Lead all exceeded NSDWQ and WHO limits except Magnesium (Table 4.8). This indicates that the chemical properties and heavy metal concentration of the water exceed permissible limit and as such the water is not safe for drinking due to contamination from waste dump.

Table 4.5: Summary of Physico-Chemical Characteristics of Leachates and Control Samples from the Wastes

PARAMETERS	SW1	SW2	SW3	SW4	SW5	SW6	WW	SWC	Mean	SD	CV (%)	NSDWQ	WHO
PH	5.37	5.12	4.93	5.19	4.6	5.51	5.21	6.38	5.289	0.520	9.835	6.5-8.5	6.5-8.5
Temperature	28.3	28	27.3	28.1	28	27.3	27.5	28.5	27.875	0.456	1.636	Ambient	Ambient
Colour	18	24	15	12	15	17	18	8	15.875	4.704	29.630	15	10
Turbidity NTU	6.5	5.1	4.3	6.3	4.9	5.3	7.2	4.1	5.463	1.101	20.148	5	10
Electrical Cond	132.1	16.5	114	96	138	125	215	198	129.325	61.217	47.336	1000	1000
Salinity as Cl	68.3	51.8	49.3	54.2	39.5	61.5	65.3	35.5	53.175	11.726	22.051		250
Total Dissolved Solids	71.1	82.3	59.1	48	74	60.3	107.5	89	73.913	18.937	25.620	500	500
Total Suspended Solid	1.513	1.147	0.913	0.817	0.539	1.001	3.814	0.094	1.230	1.125	91.462	10	<10
Total Hardness	210	180	190	160	200	190	251	110	186.375	40.560	21.763	500	500
Nitrate	6.917	4.134	5.078	5.139	5.584	4.117	5.1104	2.941	4.878	1.177	24.138	50	200
Sulphate	4.812	4.003	5.135	4.183	3.841	3.21	7.953	2.187	4.416	1.697	38.436	1000	500
Phosphate	3.784	3.517	4.101	3.403	4.011	3.131	5.301	1.243	3.561	1.144	32.114	3.5	3.5
Calcium	84	72	56	64	80	76	93.5	44	71.188	15.969	22.432	75	75
Magnesium	51.08	43.74	46.17	38.88	48.6	46.17	60.2	26.73	45.196	9.682	21.423	50.15	50-50
Potassium	8.51	5.42	6.26	4.37	6.5	4.81	9.83	2.85	6.069	2.255	37.150	1.5	10
Copper	4.137	3.984	5.01	4.013	3.187	3.98	6.719	0.814	3.981	1.658	41.651	1	1
Iron	5.431	4.819	4.282	3.948	5.019	3.195	8.304	1.901	4.612	1.868	40.493	0.3	0.3
Zinc	7.391	6.654	6.129	5.985	6.014	5.913	7.115	4.118	6.165	0.997	16.169	3	3
Manganese	3.184	3.395	3.004	2.97	3.912	4.015	5.612	1.728	3.478	1.113	32.002	0.05	
Chromium	1.483	1.73	1.189	1.114	0.975	1.307	2.039	0.094	1.241	0.579	46.616	0.05	0.5
Nickel	1.109	1.651	1.105	1.548	0.937	1.144	2.114	0.319	1.241	0.536	43.209	0.05	0.05

Cadmium	0.613	0.13	0.093	0.347	1.012	0.099	1.823	0.041	0.520	0.623	119.924	0.003	0.003
Lead	1.953	2.114	1.783	1.187	1.093	1.181	3.217	0.618	1.643	0.810	49.276	0.05	0.5

TDS: Total Dissolved Solid; TSS: Total Suspended Solid; SD: Standard Deviation; CV: Coefficient of Variation; NSDWQ = Nigerian Standard of Drinking Water Quality; WHO = World Health Organization

Research hypothesis

H_{o1}: There is no significant variability in the Physico-chemical parameters at different segments of the stream channel.

Table 4.6: ANOVA Analysis of Significant Variability in Physico-Chemical Parameters

ANOVA					
concentration					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1275.209	6	212.535	.103	.006
Within Groups	317302.668	154	2060.407		
Total	318577.876	160			

Table 4.6 shows that Analysis of Variance (ANOVA) testing for the significant differences in the concentration of pollutants at different sections of the stream. The result shows sum of square value of 1275.209, degree of freedom (df) of 6, 154, mean square of 212.535, F-value of 0.103 and P-value of 0.006. The result therefore shows that the null hypothesis is rejected (P<0.05) and can be concluded that there is a significant variability in the physico-chemical parameters at different segments of the stream channel. This corresponds to the result in Table one which shows a variability in the concentration at different segment of the stream.

4.1.4 Examine and Compare the Difference in the Quality of Sampled Surface Water with World Health Organization and Nigeria Standard for Drinking Water Quality

H_{o2}: There is no significant difference in the quality of a water sample in the area compared with the water quality standard of the World Health organization.

Table 4.7: T-Test Analysis of Differences in the quality of sampled surface water with World Health Organization and Nigeria Standard for Drinking Water Quality

Parameter	NSDWQ	WHO	MEAN	T-VALUE	P-VALUE	DECISION
pH	6.5-8.5	6.5-8.5	5.30	-5.662	0.001	Significantly lower
Colour	15	10	15.57	0.303	0.77	Insignificant
Turbidity NTU	5	10	5.21	-13.83	0.00	Significantly lower

Electrical Cond us/cm	1000	1000	117.09	-42.84	0.00	Significantly lower
Salinity as Cl mg/l		250	51.44	-45.65	0.00	Significantly lower
Total Dissolved Solids mg/l	500	500	69.11	-79.92	0.00	Significantly lower
Total Suspended Solid mg/l	10	<10	0.86	-53.56	0.00	Significantly lower
Total Hardness mg/l	500	500	177.14	-25.48	0.00	Significantly lower
Nitrate mg/l	50	200	4.84	-407.33	0.00	Significantly lower
Sulphate mg/l	1000	500	3.91	1328.02	0.00	Significantly lower
Phosphate mg/l	3.5	3.5	3.31	-0.508	0.630	Insignificant
Calcium mg/l	75	75	70.86	-0.817	0.445	Insignificant
Magnesium mg/l	50.15	50-50	43.05	-2.254	0.065	Insignificant
Potassium mg/l	1.5	10	5.53	-6.57	0.001	Significantly lower
Copper	1	1	3.59	5.14	0.002	Significantly higher
Iron mg/l	0.3	0.3	4.08	8.25	0.00	Significantly higher
Zinc mg/l	3	3	6.03	8.07	0.00	Significantly higher
Manganese mg/l	0.05		3.17	10.88	0.00	Significantly higher
Chromium mg/l	0.05	0.5	1.13	3.20	0.00	Significantly higher
Nickel mg/l	0.05	0.05	1.12	6.47	0.001	Significantly moderate
Cadmium mg/l	0.003	0.003	0.33	2.43	0.05	Significantly moderate
Lead mg/l	0.05	0.5	1.42	4.49	0.004	Significantly higher

Source: Statistical Analysis using SPSS (version 25.0)

The result as presented in Table 4.7 shows that the concentration of PH, Turbidity NTU, Electrical Conductivity, Salinity, Total Dissolved Solids, Total Suspended Solid, Total Hardness, Nitrate, Potassium and Sulphate were significantly lower than World Health Organization and Nigeria Standard for Drinking Water Quality limit. On the other hand, parameters like Copper, Iron, Zinc, Manganese, Chromium and Lead recorded a significant higher concentration above the permissible limit. Other parameters were observed to be insignificant, and they include: colour, Phosphate, Calcium and Magnesium. More so, Nickel and Cadmium recorded a higher but moderate concentration compared to their respective permissible limit. The result therefore shows that the concentration of the physio-chemical properties of the stream is deeply affected by the dumpsite.

Discussion of Findings

Result of the study shows that within Ikpa River Basin, waste management strategies are very poor. Respondents only rely on quick evacuation of waste from their neighbourhood. The second most adopted strategy is encouraged reuse and pay as you throw. Recycling and incineration are completely 0% in the study area which shows the poor extents of waste management in the study area. Consequently, it can be concluded that the extent of solid waste management in the study area is very poor. The result also shows that that waste deposited consist mainly of 21.1% biodegradable, followed by paper waste which constitute 17.3%, wood (14.23%), plastics (13.5%), metal (9.47%), textile (7.89%), among others. This shows that the main waste generated in Ikpa River basin contain mainly biodegradable products followed by wood and plastics. More so, result also indicates that the extent of waste management in the area is very poor. Not less than 60% of the respondents affirmed that the extent of waste management in the area is poor. Only 16% rated tit as fair while only 3% suggest it is excellent. This gives an indication that the extent of waste management in the study area is very poor. This was also confirmed during data gathering that major sections of Uyo-Village Road and the stream is polluted due to waste dump, and this raises concern for residents and commuters.

Conclusion

The stream remains the major source of drinking water especially for rural dwellers. But the introduction of pollutants and dumping of refuse along the river course causes pollution and rendered the water unsafe for drinking and other domestic uses. The study revealed that there is a significant variability in the physico-chemical parameters at different segments of the stream channel with parameters like colour, Phosphate, Calcium and Magnesium, Nickel and Cadmium recorded a higher concentration compare to their respective permissible limit. The study also shows that the dumpsite has negatively impacted on the health of residents of the area in terms of pollution of drinking water, loss of aesthetic value, spread of waterborne diseases, destruction of aquatic flora and fauna, threat to economic life of the people and siltation of the stream, among others. Based on findings from the study, the following recommendations are made:

- There is need for government to relocate the dumpsite to another location to safe the water from disappearance and pollution or governments should ban or discourage indiscriminate disposal of wastes within stream environments.
- There is need for public awareness and enlightenment programmes on the need for effective and efficient wastes disposal within stream environments. This is achievable through workshop/seminar, radio and television programmes, among others.
- There is need for treatment of water from the stream before drinking to prevent some health diseases and/or the rural communities should seek alternative source of drinking water.

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