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RESEARCH ARTICLE

ASSESSMENT OF THE IMPACT OF SOLID WASTE DUMPSITE ON WATER QUALITY: A CASE STUDY OF MANGO ESTATE, PORT HARCOURT, NIGERIA

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ABSTRACT
Pollution of water bodies has generated a lot of debate amongst government as well as scientist all over the world. However, the need to protect our water bodies has become necessary due to global water scarcity. This study is carried out to assess the impact of solid waste disposal on surface water quality. The samples were collected at three different locations, upstream, midstream and downstream in containers and preserved before they were taken to the laboratory from the field. For quality assurance (QA), the bottles were first rinsed thoroughly with distilled water, before collection of samples. Analysis was conducted for the following parameters lead, iron, Fe, chromium, cadmium, Temperature, phosphate, nitrate, sulphate, Ph, Dissolved oxygen, Total dissolved solid, Polycyclic aromatic hydrocarbon, Total petroleum hydrocarbon and Tetrahydrocannabinol. The analyses of water were carried out in accordance with standard analytical methods described by APHA (2012). Results from the study reveal a pH mean of 6.8, lead 4.699mg/L, Cadmium 2.937mg/L, Iron 5.693mg/L, Chromium 2.921mg/L, Phosphate and 10.6mg/L which were all higher than the permissible limit with the exception of sulphate and nitrate which were below the permissible limit. The study showed an increased concentration of DO, TDS, PAH, TPH and THC for all the samples analyzed in the study. Results from WQI revealed that all samples calculated were above 100 meaning that the water is not good for drinking nor cooking. The study therefore recommended that government agencies should be proactive and monitor our waterbodies to ensure that dumpsites are not located around them as well as improving industrial waste management, enforcing stricter regulations, and enhancing water treatment processes to ensure safe and sustainable water quality for the community.

Keywords: Assessment**,** impact, solid waste, pollution, water quality, sustainability.

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1.0. INTRODUCTION

The generation of municipal solid waste from activities of man has become a serious challenge especially in urban dwellings due to the rapid increase in population and change of lifestyle of the urban dwellers. Hence, the increase in waste generation which have grown proportionally with strong economic growth (Bhat *et al.*, 2022). The constant rise in population, along with rapid industrialization and urbanization, has a direct impact on solid waste creation (Agunwamba, 2019; Agunwamba, 2003) as noticed in major cities in developing nations. Urbanization and municipal operations have increased the quantity of waste stream created, consequently contaminating our ecosystem (Ugbegbor and Ntesat (2019). The dumping and release of waste in water bodies has affected several freshwater bodies (Bhat et al., 2018) thereby reducing their ecosystem functions.

Similarly, municipal solid waste is disposed of in rivers and streams by individuals who live along the river's banks, and it has lately become a business for others who pay for a spot near water bodies to accept rubbish from trucks and people for a fee (plate 1). Untreated municipal solid waste could be a challenge to the health of man as well as environment due to its toxic nature, extent of mutation, and carcinogenic tendency (Zhu et al., 2021). In addition, solid waste dumping site, create home for insect like mosquitoes, rats, creeping animals and other related insects to thrive and as such increases the incidences of infections and diseases like diarrhea, asthmatic conditions, respiratory conditions and even cancer (Eshete, Haddis, & Mengistie,2024). People that reside close to these dumpsites, are confronted with various health challenges from these insects and animals that are drawn to these areas because of the presence of the dumpsite (Ali, 2018; Abuye, Jegora, Gamachu, 2019; Wondimu, 2020; Aklilu, Sahilu, Ambelu, 2024; Eshete, Haddis, & Mengistie,2024; Berhanu et al., 2022).

Most wastes are dumped into receiving bodies of water with little to no regard for their absorption capacity (Riccardo, 2021). Rivers are becoming polluted due to dumping of effluent and solid waste (Acholonu et al., 2023). Growing urbanization and informal settlements have led to indiscriminate waste disposal near rivers, which can harm water quality (Lazola et al., 2023) as well as affect the functioning of aquatic organisms. This is because, illegal waste dumping along riverbanks endangers the ecosystems and the various organisms that live there (Malinowski et al. 2015). Human activities, industrial, and municipal discharges have caused significant environmental deterioration and pollution in Nigeria's coastal areas, notably the Niger Delta Basin (Ugbegbor and Ntesat, 2019). According to the USEPA (2002, 2005) and Bhat (2018), improperly managed solid waste pollutes our rivers, attracts insects and rats, and raises flood risk by clogging drainage water systems. Food, paper, polythene bags, dyes, metals, and other hazardous materials are among the MSW contents (Ahmed, 2020) that are found in these water bodies.

Untreated municipal solid waste produces leachate, which eventually enters water bodies and impacts numerous components of freshwater ecosystems (Bhalla, 2012). Untreated waste and leachates have negative consequences on freshwaters (Bhat, 2018). Generally, dumpsites impact all circle of man's life (Tilaye & van Dijk, 2014), thereby making sustainable management of solid waste a necessity for the management of our urban environment (Tilaye & van Dijk, 2014).

Many of these wastes are non-biodegradable and will remain in the environment for an extended length of time (plate 5). Because of their fragility, they lose resistance and suffer irreversible deterioration with no prospect of restoration as a result of continual garbage dumping and other toxic ingredients (Lohri, 2014). These substances in form of heavy metal can reach the human body through the food chain and cause illnesses (Haseena Malik et al., 2017). The toxic nature of heavy metals such as cadmium, zinc, Iron, chromium, Nickel, copper etc. makes it a worrisome situation. Additionally, is the activities of other microbial pollutants like coliforms and pathogens, that are capable of causing toxic harm to human health as well as other animals in the environment (Ewusi, Sunkari, Seidu, Coffie-Anum, 2022; Gerba & Pepper, 2019) especially when elevated concentration are found in surface and groundwater. They can be harmful to the human organs, impair nervous system, cause cancer as well as cause a disorder among aquatic organism as microbial pollutants have the tendency to cause waterborne diseases and degrade our environment (Pal et al., 2018; Hassen et al., 2023; Ewusi, Sunkari, Seidu, Coffie-Anum, 2022; Gerba & Pepper, 2019).

Furthermore, this method of dumping waste in and around the vicinity of water bodies faces various sustainability difficulties, including resource depletion, environmental degradation, and public health issues, such as the spread of infectious illnesses (Abubakar et al., 2022). Several human activities contribute to the contamination of surface water, and it is difficult to restore its purity after contamination. Many towns have been known to suffer from lack of safe drinking water, with many relying on rivers, wells, rains, and boreholes and hence, are exposed to the danger of contaminated water from dumping of solid waste. This is the situation with the study area as many of the people rely on this river for the daily water requirement such as bathing and washing and economic empowerment as some of them are fishermen. Consequently, the health of humans as well as the ecosystems is jeopardized because aquatic species such as fish accumulate these toxins both directly from dirty water and indirectly through bioaccumulation in the food chain (Acholonu et al., 2023). Because of their influence on health, oxygen-demanding wastes such as sewage are among the most serious toxins in our natural environment (Acholonu et al., 2023). These recognized consequences highlight the need of assessing the effects of these dumpsites on the water quality of the study area.

2.0. STUDY AREA

The study was carried out at, Mango estate waterside, Elelenwo community in Port Harcourt city, Obio Akpor, Rivers state (Figure 1). The area as observed has a large open dump site which never properly maintained. It serves as a point of waste collection; the waste in the

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areas consist majorly of rubber, plastics, polyethene (plate 4), yard waste and food waste is left without treatment throughout the year. Leachates from the sites flow into the water body (Plates 2 & 3), and the unpaved roadways and could consequently seep into groundwater. The study area falls within a living area, with under-developed facilities, such as uncompleted houses and houses made of aluminium, the primary occupation of occupants are fishing.

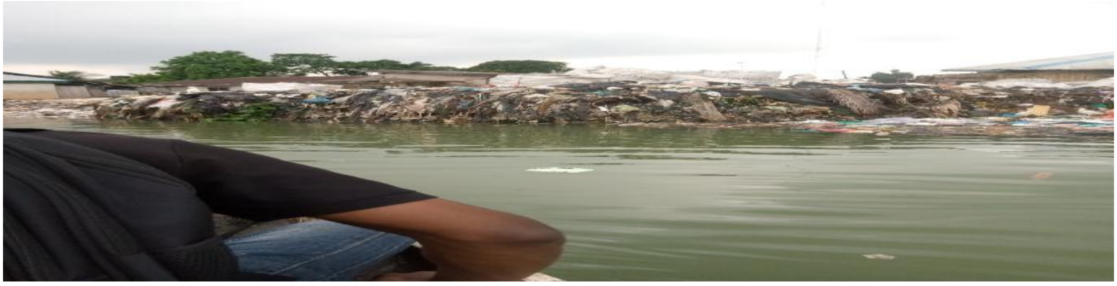

Plate 2: Dumpsite flowing into the water

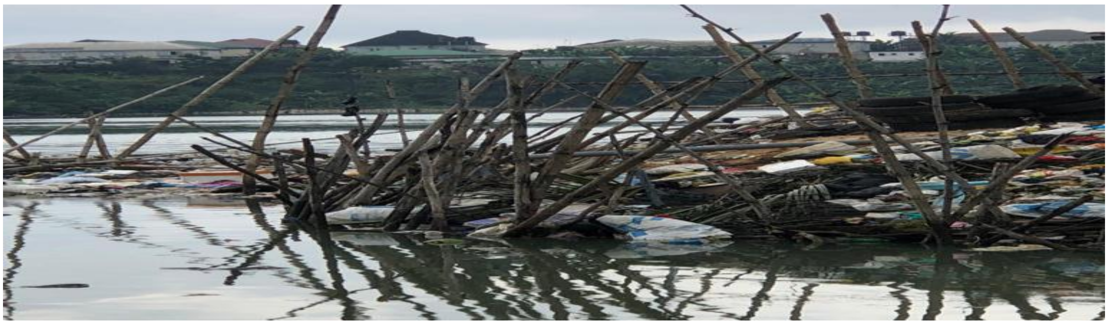

Plate 3: Local embarkment to restrict waste into the water body

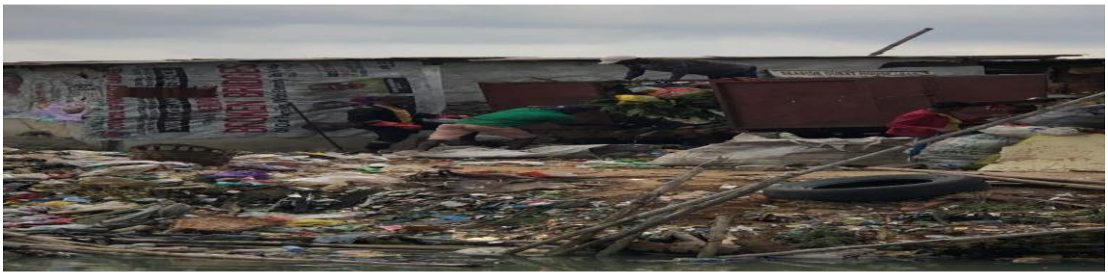

Plate 1: Activities of trunks discharging waste by the river bank

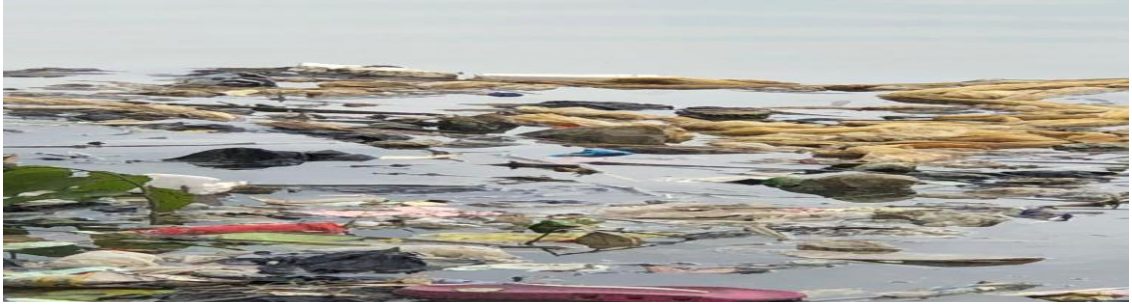

Plate 4: overflow of solid waste from the dump into the water body

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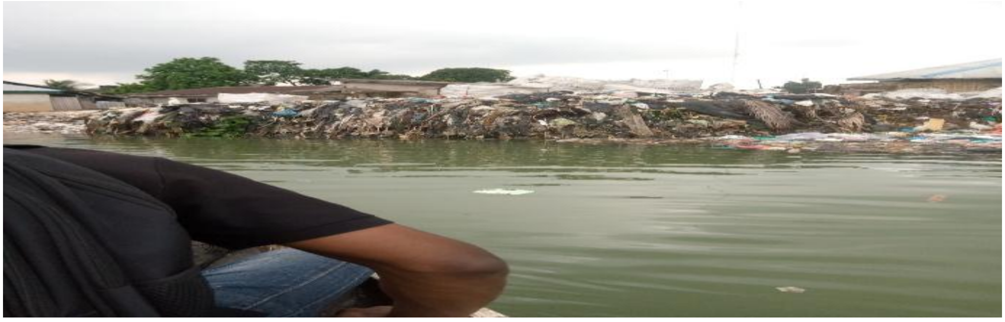

Plate 5: Compressed solid waste over a period of time

3.0. MATERIALS AND METHODS

3.1. Sample Collection

The samples were collected at three different locations, upstream, midstream and downstream in containers and preserved before they were transported to the laboratory from the field. For quality assurance (QA), the bottles were first rinsed thoroughly with distilled water, before collection of samples. The instruments were used in situ and ex situ for this research include Global Positioning System (GPS), polyethene gloves, and sampling bottles.

Table 1: Sampling locations and Coordinates

Location	Coordinates Latitude (N)	Longitude (E)
Upstream	4.826503	7.069145
Midstream	4.823417	7.070439
Downstream	4.822159	7.070819

2.3. Water Sample Analysis

All the samples were analyzed for the following parameters lead, iron, Fe, chromium, cadmium, Temperature, phosphate, nitrate, sulphate, Ph, Dissolved oxygen, Total dissolved solid, Polycyclic aromatic hydrocarbon, Total petroleum hydrocarbon and Tetrahydro-cannabinol. The analyses of water were carried out in accordance with standard analytical methods described by APHA (2012).

In an effort to investigate the extent of water contamination, three sampling points were designated, namely Upstream, Midstream, and Downstream. Water samples were collected in 1 liter plastic containers and prior to collection as part of quality control measures all the bottles were washed with nonionic detergent and rinsed with de-ionized water prior to usage. Before the final water sampling was done, the bottles were rinsed three times with water at the point of collection. Each bottle was labelled according to sampling location while all the samples were preserved at 4°C and transported to the laboratory. In situ assessment of various parameters was carried out by the use of digital portable multi-parameter probe (Micro 800 plain test, UK model).

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2.4. Water Quality Index (WQI)

Water quality index (WQI) provides a single number that expressed the general water quality at a certain location and time based on several water quality parameters. The objective of WQI is to transform numerous water quality data into information that is understandable and usable by the public. Calculation of WQI given in Equation 2.1 as:

$$WQI = \sum \frac{QiWi}{\sum Wi} \qquad (2.1)$$

The quality rating scale (Qi) for each parameter calculated from Equation 2.2.

$$Qi = \left[\frac{Vi - Vo}{Si - Vo}\right] \times 100 \qquad (2.2)$$

Where; Vi = estimated concentration of ith parameter in the analyzed water

Vo = the ideal value of this parameter in pure water. It is equal to zero for all parameters (except pH = 7.0 and DO = 14.6 mg/l)

Si = recommended standard value of ith parameter.

Also, the unit weight (Wi) for each water quality parameter was calculated from Equation 2.3;

$$Wi = \frac{k}{Si} \qquad (2.3)$$

Where; k = proportionality constant and can be evaluated from Equation 2.4

$$K = \frac{1}{\sum 1/Si} \qquad (2.4)$$

4.0. PRESEMTATION OF RESULTS AND DISCUSSIONS

The result of the laboratory analysis of the water sample collected at the waterside is presented in table 2 and compared with the WHO standard. Respective parameters in relations to W.H.0 Standard were discussed and depicted with the aid of tables.

Physiochemical and heavy metal concentrations of samples

Temperature

The study as shown in table 2 revealed a temperature of 25.8°C for upstream, 26.7°C for midstream and 25. 9°C for downstream with a mean value of 26.1mg/L which were higher than the permissible limit of W.H.O. The elevated temperature in the study area could be an indication of thermal pollution resulting from industrial waste.

Lead (Pb)

The result for lead for upstream was 0.01mg/L, midstream 3.892mg/L, downstream 6.182mg/L with a mean of 4.699mg/L which are higher than the W.H. O limits of 0.01. The high levels of lead recorded in all the sampled location could be an indication of contamination resulting from either industrial or agricultural waste.

Table 2: Parameters concentration in the Up-stream, Mid-stream and Down-stream

Parameters	Upstream	Midstream	Downstream	Mean	W.H.O STANDARD
Lead mg/L	3.892	4.023	6.182	4.699	0.01
Iron mg/L	5.168	5.892	6.018	5.693	0.3
Chromium mg/L	1.389	2.892	4.482	2.921	0.05
Cadmium mg/L	2.106	3.142	3.562	2.937	0.003
Temperature (^{0}C)	25.8	26.7	25.9	26.1	22
Phosphate mg/L	10.4	10.6	10.8	10.6	0.5
Nitrate mg/L	15.7	15.9	15.7	15.77	50
Sulphate mg/L	56.4	57.9	59.3	57.87	250
pH	6.8	6.9	6.8	6.8	6.5-8.5
DO	5.5	4.8	6.0	5.43	≥5.0
TDS	6215	6245	6374	6278	600
PAH	1.3967	1.2389	2.7747	1.803	< 0.001
TPH	4.2699	3.2263	5.7747	4.42	< 0.001
THC	6.238	5.226	8.989	6.82	<0.001

Source: Laboratory Analysis (2024).

Iron

Table 2 also revealed the values for Iron at upstream to be 5.168mg/Midstream 5.892 and downstream 6.018mg/L with a mean of 5.693mg/L indicating severe contamination when compared with W.H.O standards although not as high as lead. The increase in Iron concentration can be attributable to waste from industrial activities. Excess amount of iron (more than 10 mg/kg) is capable of causing sharp increase in pulse rate and blood coagulation in vessels, as well as hypertension (Acholonu et al., 2023)

Chromium

Similarly, Chromium also shows a mean value of 2.921 and concentration levels for upstream as 1.389mg/L, midstream 2.892mg/L and downstream 4.482mg/L. From the results, it shows that the concentration of chromium is very high especially at the downstream which poses great danger to the environment.

Cadmium

From Table 2, cadmium concentration level shows a mean of 2.937 and upstream 2.106mg/Midstream 3.142mg/L and downstream 3.562mg/L which are above the W.H.O limits. Based on the W.H.O standards, cadmium level should be 0.003mg/L, however, result showed that the sampled water had higher level of cadmium compare to the acceptable limit. Several literatures have reported the harmful effects of cadmium (Rani et al., 2014; Patrick, 2003; Kaji,2012; Berglund et al.,2014; Bernhoft, 2013) the exposure of humans to cadmium could result in severe health challenges.

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Phosphate

Phosphate concentration level ranged from 10.4mg/L for upstream, 10.6mg/L for midstream and 10.9mg/L for 10.8mg/L for downstream. which are above the W.H. O limits of 0.5mg/L. The result showed that concentration was higher at downstream where solid waste was closest.

Nitrate

Nitrate were lower in all sampled location as compared to W.H.O limits. Concentration level for upstream showed a concentration value of 15.7mg/L, midstream 15.9mg/L and downstream 15.7mg/L as shown in table 2. From the results, Nitrate pollution does not pose problem yet to the study area.

Sulphate

The concentration of sulphate as shown in Table 2, reveal a concentration mean value 57.87mg/L and upstream concentration of 56.4mg/L, midstream 57.mg/L and downstream concentration of 59.3mg/L which are all lower than the W.H.O standards of 250mg/L. This result shows that sulphate contamination is not yet a problem in the study area.

pH: A pH means concentration value of 6.8 was obtained for the study with upstream having a pH value of 6.8, midstream 6.9 and downstream 6.8 as shown in table 2. The result showed that the water is slightly acidic.

Dissolved Oxygen (DO)

The concentration level for DO reveal a concentration value of 6.0mg/L for upstream, 5.5mg/L for midstream and 4.8mg/L for downstream. The mean value concentration of 5.43mg/L shows that DO concentration exceeded the permissible limit of 5.0mg/L by W.H.O with midstream having a lower DO.

TDS (Total Dissolved Solid)

The concentration values recorded for Total dissolved solid varied from 621mg/L for upstream, 6245mg/L for midstream and 6374mg/L for downstream. The results shows that the downstream had more concentration of TDS. All values were above the permissible limits of W.H.O.

PAH (Polycyclic aromatic hydrocarbon)

The PAH concentration values for sampled water varied from 1.3967mg/L for upstream, 1.2389mg/L for midstream and 2.7747mg/L for downstream and a mean value of 1.803mg/L. The results show that the water in this study area, is highly contaminated from pollutants that could be originating from vehicles.

TPH (Total petroleum hydrocarbon)

TPH concentration values showed similar elevated concentration with upstream values of 4.2699mg/L, midstream3.2263mg/L and 5.7747mg/L and a mean value of 4.42. All values were higher than W.H.O limits of < 0.001 indicating a highly contaminated water body.

THC (Tetrahydrocannabinol)

The concentration value for THC varied from 6.238mg/L for upstream, 5.226mg/L for midstream and 8.989mg/L for downstream. Showing that the downstream was more contaminated than upstream and midstream.

4.1. Water Quality Index (WQI) Calculation

The WQI value for the different water samples were calculated using Equations 2.1 to 2.3 as shown in Tables 3 to 5 for upstream, midstream ad downstream.

Table 3: WQI values for upstream

Parameter	Si	1/Si	Wi= k/Si	Vi	Vo	Qi = [(Vi-Vo)/(Si-Vo	Qi x Wi
Lead mg/l	0.01	100	0.0289101	3.892	0	38920	1125.181092
Iron mg/l	0.3	3.333333333	0.00096367	5.168	0	1722.666667	1.660082187
Chromium mg/l	0.05	20	0.00578202	1.389	0	2778	16.06245156
Cadmium mg/l	0.003	333.3333333	0.096367	2.106	0	70200	6764.9634
Temperature	22	0.045454545	1.3141E-05	25.8	0	117.2727273	0.001541076
Phosphate mg/l	0.5	2	0.000578202	10.4	0	2080	1.20266016
Nitrate mg/l	50	0.02	5.78202E-06	15.7	0	31.4	0.000181555
Sulphate mg/l	250	0.004	1.1564E-06	56.4	0	22.56	2.60885E-05
pH	8.5	0.117647059	3.40119E-05	6.8	7	-13.33333333	-0.000453492
DO	5	0.2	5.78202E-05	5.5	0	110	0.006360222
TDS	600	0.001666667	4.81835E-07	6215	0	1035.833333	0.000499101
PAH	0.001	1000	0.289101	1.3967	0	139670	40378.73667
TPH	0.001	1000	0.289101	4.2699	0	426990	123443.236
THC	0.001	1000	0.289101	6.238	0	623800	180341.2038
		3459.055435					352072.2543

Table 4: WQI values for Midstream

Parameter	Si	1/Si	Wi= k/Si	Vi	Vo	Qi = [(Vi-Vo)/(Si-Vo	Qi x Wi
Lead mg/l	0.01	100	0.0289101	4.023	0	40230	1163.053323
Iron mg/l	0.3	3.333333333	0.00096367	5.892	0	1964	1.89264788
Chromium mg/l	0.05	20	0.00578202	2.892	0	5784	33.44320368
Cadmium mg/l	0.003	333.3333333	0.096367	3.142	0	104733.3333	10092.83713
Temperature	22	0.045454545	1.3141E-05	26.7	0	121.3636364	0.001594834
Phosphate mg/l	0.5	2	0.000578202	10.6	0	2120	1.22578824
Nitrate mg/l	50	0.02	5.78202E-06	15.9	0	31.8	0.000183868
Sulphate mg/l	250	0.004	1.1564E-06	57.9	0	23.16	2.67823E-05
pH	8.5	0.117647059	3.40119E-05	6.9	7	-6.666666667	-0.000226746
DO	5	0.2	5.78202E-05	4.8	0	96	0.005550739
TDS	600	0.001666667	4.81835E-07	6245	0	1040.833333	0.00050151
PAH	0.001	1000	0.289101	1.2389	0	123890	35816.72289
TPH	0.001	1000	0.289101	3.2263	0	322630	93272.65563
THC	0.001	1000	0.289101	5.226	0	522600	151084.1826
		3459.055435					
		0.000289101					
		0.000289101					291466.0208

Table 5: WQI values for Downstream

Parameter	Si	1/Si	Wi= k/Si	Vi	Vo	Qi = [(Vi-Vo)/(Si-Vo	Qi x Wi
Lead mg/l	0.01	100	0.0289101	6.182	0	61820	1787.222382
Iron mg/l	0.3	3.333333333	0.00096367	6.018	0	2006	1.93312202
Chromium mg/l	0.05	20	0.00578202	4.482	0	8964	51.83002728
Cadmium mg/l	0.003	333.3333333	0.096367	3.562	0	118733.3333	11441.97513
Temperature	22	0.045454545	1.3141E-05	25.9	0	117.7272727	0.001547049
Phosphate mg/l	0.5	2	0.000578202	10.8	0	2160	1.24891632
Nitrate mg/l	50	0.02	5.78202E-06	15.7	0	31.4	0.000181555
Sulphate mg/l	250	0.004	1.1564E-06	59.3	0	23.72	2.74299E-05
pH	8.5	0.117647059	3.40119E-05	6.8	7	-13.33333333	-0.000453492
DO	5	0.2	5.78202E-05	6	0	120	0.006938424
TDS	600	0.001666667	4.81835E-07	6374	0	1062.333333	0.000511869
PAH	0.001	1000	0.289101	2.7747	0	277470	80216.85447
TPH	0.001	1000	0.289101	5.7747	0	577470	166947.1545
THC	0.001	1000	0.289101	8.989	0	898900	259872.8889
		3459.055435					
		0.000289101					
		0.000289101					520321.1162

Table 6: Water Quality Index Results

Locations	Index Value	Water Quality Status
Upstream	352072.2	Unsuitable for drinking
Midstream	291466.0208	Unsuitable for Drinking
Downstream	520321.1162	Unsuitable for Drinking

According to (Gorde et al 2013), water is unsuitable for drinking when the WQI is greater than 100.Tables 3 to 5 showed the detailed calculation of the WQI for the different sample points while table 6. shows the water quality status of each sampled location indicating that the water in this study area is unsuitable for drinking. The WQI values calculated were above 100, which means the water is not suitable for cooking or drinking. From the calculation of WiQi for the three samples, it was observed that all the parameters measured were above the permissible limits as shown in table 2 except for Nitrate and sulphate.

5.0. CONCLUSION

Findings of this research, shows that solid waste dumpsite in the vicinity of water body poses a great risk to both man and the environment. All parameters assessed exhibited high concentration level when compared with W.H.O permissible limits. Of particular concerns were lead, Iron, cadmium, phosphate TDS, PAH, TPH and THC which were well above the standard set by W.H.O. The overall results obtained from WQI calculation for upstream, midstream ad downstream samples respectively, shows that the water located at different distances to the dumpsite is unsuitable for drinking since the WQI is greater than 100. Hence it is unsuitable to be used for drinking or cooking. From the results of WQI, it shows that the water is not suitable, wholesome and portable. Government agencies should be proactive and monitor our waterbodies to ensure that dumpsites are not located around them as well as improving industrial waste management, enforcing stricter regulations, and enhancing water treatment processes to ensure safe and sustainable water quality for the community. This study is particularly important as people live around these dumpsites who depend on surface water and groundwater directly or indirectly for their water needs.

Competing Interest

The authors have declared that no conflicting interest exist in this manuscript.

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