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Investigation of the Impact of Solid and Liquid Wastes Disposal Sites on Surface and Ground Water Resources in Minna Town, Niger State, Nigeria: A Risk Assessment for Clean Water and Sanitation, Good Health and Wellbeing

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ABSTRACT

In this study, an investigation of solid, liquid wastes disposal sites, their impacts on the environment, the risk posed to clean water and sanitation (Sustainable Development Goals, SDG 6), good health and wellbeing (Sustainable Development Goals, SDG 3) in Minna town, was undertaken. Water samples from streams, boreholes and hand dug wells close to the dumpsites including the raw and treated effluent samples from industry(ies) operating within the area were collected and analysed for physico-chemical parameters and heavy metals. Results showed that the mean concentration values of the physico-chemical and heavy metals parameters analysed during the study period were all within the acceptable limits of NSDWQ and WHO standards for drinking water quality guidelines, except for the concentrations of turbidity at Kuyi village (9.3 NTU and 16.6 NTU) and the downstream close to Maitumbi dumpsite (99.9 NTU) were above the permissible limit of 5NTU. All the Heavy metals except Cadmium comply with the standard. The physico-chemical and heavy metals parameters analysed for effluent samples from the industry are all within permissible limits of FEPA, except chloride and salinity with higher values above the specified limits. The concentrations of heavy metals in the effluent's samples are all below the permissible limits specified by FEPA. It was also observed that wastes generated are dumped in an uncoordinated manner with obnoxious smell emanating from the dumpsites, which invariably end up in surface and groundwater sources in the vicinity, andthis may lead to a disaster if unchecked. It is recommended that government should introduce control measures such as providing good site for wastes dump far away from drinking water sources, as well as monitoring and enforcing strict regulations concerning industrial effluent discharges to be treated before releasing into the environment.

Keywords: Clean water and sanitation; dumpsites; environment; health and wellbeing; liquid and solid wastes; surface and groundwater

1. Introduction

In as much as life continues to exist on this earth, waste must be generated, either directly or indirectly due to activities of living organisms (Siddiqua *et al.,* 2022). It has been estimated that 125 million tons of municipal solid waste (MSW) were generated in Africa in 2012, which is expected to double by 2025 (Kang *et al.,* 2023; Zhang*et al.,* 2024). The growth in waste generation in Africa is expected to be so significant, in such a way that, any decrease in waste generation in other regions globally will be overshadowed by Africa (Orhorhoro & Oghoghorie, 2019; Godfrey *et al.,* 2019). The average MSW collection rate is only 55 % and more than 90 % of waste produced in Africa is disposed of at uncontrolled dumpsites and landfills, often with associated open burning. About 19 of the world's 50 biggest dumpsites are located in Africa, and all in Sub-Saharan Africa (Adusei-Gyamfi *et al.,* 2022; Adedara *et al.,* 2023). Nigeria being the most populated country in that region, the quantity of solid waste generated in Nigeria is increasing because of increase in her population that is estimated in 2022 at 218,541,212 persons, which accounts for nearly half the total population of West Africa, and more than 15 % of the total population of Africa (Orhorhoro, 2019). The population density in Nigeria is 205 per km^2, and the total land area is 910,802 km^2. Estimated 48.1 % of the population lives in urban areas, while the rest based in the rural areas, with farming as their major occupation (Orhorhoro, 2019). According to Onipede *et al*. (2004) waste management is a problem in urban and industrialized areas of the country. Many industrialized cities in Nigeria still have inadequate waste management, poorly controlled open dumps and illegal roadside dumping remain a problem (Dinkin, 2018). As if this is not enough, the inability of governments, individuals and waste disposal firms to keep up with the task of managing waste and the environment is worrisome (Ogwu, 2018). The percentage of Nigeria's population living in cities and urban areas are more than doubled in the last 15 years leading to uncontrolled and poorly managed waste in fast growing capital cities (Ogwu, 2018).

There are possible risks to environment and healthfrom improper handling of solid wastes. Improperwaste management causes all types of pollution: air,soil, and water. Indiscriminate dumping of wastes contaminates surface and ground water supplies (Alam & Ahmade, 2013; Kwun Omang *et al.,* 2021; Donuma *et al.,* 2024). Inurban areas, solid waste clogs drain, creating stationarywater for insect breeding and floods during rainy seasons. Unrestrained burning of waste and improper incineration also support significantly to urban air pollution. Greenhouse gases are produced from the decomposition of organic wastes in landfills, and untreated leachate pollutes nearby soil and waterbodies (Prakash, 2017; Ogbonna & Udotong, 2021; Ozoh *et al.,* 2021).

Improperly managed waste can attract rodents and insects, which can harbour gastrointestinal parasites, yellow fever, worms, the plague and other circumstances for humans, and contact with hazardous wastes, mostly when they are burned, can cause variousother diseases including cancers. Toxic waste materials can contaminate surface water, groundwater, soil, and air which cause more difficulties for humans, other species, and the ecosystems (Prakash, 2017; Kumar & Kumar, 2020). Waste treatment and disposal produces important greenhouse gas emissions, particularly methane, which adds to global warming effects. Health and safety issues also manifest from inappropriate waste management. Insect and rodent vectors are fascinated to the waste and can spread diseases such as cholera and dengue fever. Using water polluted by municipals waste for bathing, food irrigation and drinking water can also predispose individuals to disease organisms and other contaminant (Prakash, 2017; Zikhathile *et al.,* 2022).

Water is a vital requisite of human and industrial development and it is the main delicate piece of the surroundings and hence a non-stop observation of quality of water is extremely necessary to ascertain the status of effluence in our rivers, hand dug wells and boreholes. The inappropriate disposal of solid and liquid waste at chosen sites in Minna town, Nigeria, is significantly impacting the quality of surface and groundwater resources, posing a serious threat to public health due to potential contamination from leachate percolation, leading to elevated levels of harmful pollutants in drinking water sources and potentially disrupting the local ecosystem

The research was aimed at investigating the impact of solid and liquid waste management disposal (landfill) practices on surface and ground water resourcesand the public health risk posed to the environment in Minna town, North Central Nigeria.

2. Methodology

2.1 The Study Area

Minna is the capital city of Niger State, located in North Central Nigeria between longitude 6°25" E and 6°45" E and latitude 9°24" N and 9°48" N, (Figure 1). The rainy season starts in April and ends in October. The mean monthly temperature is highest in March at 38.5 °C and lowest in August at 25.1 °C. Two major streams dissect the town, each beginning from Paida hill at different points, but conjure somewhere at Keteren Gwari where it moved to be joined by another tributary (Tunga stream) at Kpakungu. Most of the inhabitants are involved in farming. Cotton, shea nuts, yams, and peanuts (groundnuts) are cultivated both for export and for domestic consumption (Popoola *et al.,* 2016; Folorunso, 2018).

Figure 1: Map of Niger State showing Minna town - the project location

2.2 Status of Dump Sites Visited, Sample Location and Collection

The dump sites in Minna town were visited for visualization and to ascertain how close they are to surface and groundwater, including the nature of wastes, local geology, land use pattern and human activities around the sites. The location of solid waste dump sites and their mode of operation were identified through government approval and size, and for the non-government approved ones, size was considered. The industries that generate liquid wastes were also identified. Onsite measurements of geographical coordinates (latitude (°N) and longitude (°E)), using the GPS. The samples were collected from the effluent channels leading to the receiving river/streams and surrounding boreholes, hand pumps and hand dug wells. GPS coordinates were also recorded at each sampling station. One litre plastic bottle was used for sample collection and tightly closed. Each bottle was rinsed with the appropriate amount of sample before final collection. The samples were preserved in a cooler box and was protected from direct sunlight and then transported to the laboratory for analysis following the methods of Lloyd *et al.* (2022) and Agoro *et al.* (2020).

2.3 Physico-chemical and Heavy Metals Analyses

The physico-chemical parameters were determined according to procedures outlined in the Standard Method for the Examination of Water and Wastewater (APHA, 1992). These parameters are electrical conductivity, suspended solids, dissolved solids, total solids, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD). Two basic techniques were used: Gravimetric and Volumetric techniques. The gravimetric technique was used to analyse total solids, dissolved solids and suspended solids, while the volumetric technique was used to determine the concentration of BOD and COD (Aniyikaiye *et al.,* 2019; Ma *et al.,* 2020).The equipment and instruments used in this study were all calibrated to check their status before and in the middle of the experiments. All glass wares were cleaned with 10% concentrated HNO_3 in order to oxidize and remove impurities on the container surfaces (Zhang & Hu, 2019). The concentration of the heavy metals in the effluent and water samples was determined using Atomic Absorption Spectrometer (SCHIMADZU AAS model AA7000) according to Islam *et al.* (2016) and Jasim *et al.* (2020). The method is commonly used due to the reproducibility of results, short analysis time, cost effective, lower-level detection and hyphenated in nature.

2.4 Quality Control

All quality control measures were followed, for each analytical batch of samples processed, blanks were carried throughout the entire sample preparation and analytical process. These blanks were useful in determining if samples were being contaminated. Replicate samples were processed on a routine basis (Behzadimoghadam & Feizi, 2019; Dawson *et al.,* 2023; Smee *et al.,* 2024). A replicate sample is a sample brought through the whole sample preparation and analytical process. Replicate samples were used to determine precision and the sample load will dictate the frequency, 5 % was adapted (Robbat, 1999).

The results obtained from the laboratory analysis of samples were entered directly into Microsoft excel and presented in the form of tables.

3. Results and Discussion

3.1 Conditions of Sampled dumpsites

In order to determine whether there are factors that could influence surface and groundwater pollution, the dumpsites were visited to examine the size, land use pattern, local geology, depth, surface/groundwater, nature of wastes,types of rocks, human activities around the area and locations were recorded as shown in Table 1.

Table 1: Status of dumpsites visited with locations, size, types of rocks, land use pattern

S/No	Dumpsite Location	Government Approved	Estimated Size	Previous Site Use	Local Geology	Depth (m)	Surface/Groundwater	Nature of Waste	Human Activities Around the Site
1	Korokpa[1] N09°31' 6.5" E06° 34' 3.9"	Not approved	800 m x 35 m	Old laterite excavated site	Slightly weathered granite gneiss	2.0	Pond containing water from rainfall (see Figure2(b); Appendix II)	Household waste	Farming, cattle rearing, poultry farm, scattered settlements (Figure6; see Appendix II)
2	Korokpa[2] N09°31' 17.6" E06° 34' 44.9"	Not approved	-----------	Old laterite excavated site	Slightly weathered granite gneiss &hardpan	1.5	Seasonal stream, 3m wide	No waste It is at upstream	Farming, cattle rearing(Figure. 1; see Appendix II)
3	Korokpa[2] N09°31' 26.4" E06° 34' 52.9"	Not approved	Outskirt of Korokpa	Litters of waste	gneiss & weathered schist	0.0	Lined hand dug well SWL= 1.85 m	Polythene bags & farm waste	Block making, local gold Processing & farming
4	Angua Maitumbi N09°37' 41.2" E06° 36' 00.9"	Not approved	Greater than 1 m^2	Old sand mining site	Granite Gneiss	3.0	Stream at the sloppy end	Household & tailings	Farming & gold processing (Figure. 7; see Appendix II)
5	Outskirt of Kuyi Village N09°40' 45.3" E06° 25' 52.8"	Govt. approved	20 m wide along the road	Farming	Silty sand	0	Stream channel	Household	Farming &cattle rearing (Figure.8; see Appendix II)

Some of the dump sites are old laterite excavation sites, with fairly weathered basement rocks underlying them. These rocks offer resistance to seepage of leachate to the groundwater table (See Table 1, Appendix I - Figure 1(a). It was observed that the depth of old excavation is about 2 m depth at the interior parts of Korokpa dumpsite (see Table 1, Appendix I - Figure 1(b). There exist predominantly farming activities around the dump site(see Table 1, Appendix I - Figure 1(c). There also exist dumpsite close to pond and scattered settlement around the photograph of Korokpa dumpsite (see Table 1, Appendix I - Figure 1(d).Local gold processing pits and activities going on within the area (see Appendix II -In Fig 2(a). Area yet to be filled up within of Korokpa dumpsite (the seasonal pond provides water for cattle) (see Table 1, Appendix II - Figure 2(b). Residential buildings, and poultry farm around present in the area, with very offensive odour towards the stream marking the end of Korokpa dumpsite (see Table 1, Appendix II - Figure 2(c). Heaps of scavenged plastic materials from government approved dump site near Kuyi village was also observed (see Table 1, Appendix II - Figure 2(d). Limited waste disposal facilities and uncontrolled-temporary wastes disposal sites was predominant within the urban areas of Minna town. The basement rocks within the dump sites have irregular orientations in term of depth to the surface, thereby limiting the volume of waste they would have taken.

3.2Effluents Samples from Industry

In order to confirm the level of concentrations of raw and treated effluent samples from the industry, the physico-chemical and heavy metal analysis of the effluents samples from industry was undertaken and the values gotten were compared with the Federal Environmental Protection Agency (FEPA, 1991) water and effluent quality guidelines values and the results are presented in Table 2.

3.3 Physical Parameters

3.3.1 pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Temperature, Appearance, and Turbidity

The pH values observed for both raw and treated effluents from the effluent sample at the pharmaceutical company both recorded 8.5. The pH values were all within the permissible limit of the FEPA effluent quality guideline of 6-9 (Table 2). High value of pH has great impact on stream quality by affecting the metals solubility, alkalinity and hardness of water (Omer, 2019; Saalidong *et al.,* 2022). High conductivity level in water could be as a result of high level of conducting elements such as chloride and phosphate (Fakayode, 2005). Excessive discharge into water bodies adversely affects the human and aquatic life forms, and an indication of too much salt in the water. The concentrations of the electric conductivity of both raw and treated effluents were both within the FEPA effluent quality guideline value

Table 2: The quality of the industrial effluent sample at DANA Pharmaceutical Company Ltd

S/N	Parameters	DANA Pharm Raw Effluent	DANA Pharm Treated Effluent	Max Permissible Limit FEPA*
		N09^{0} 38’03.8$^{″}$ E006^{0}34’53.7$^{″}$	N09^{0} 38’04.3$^{″}$ E006^{0} 34’53.3$^{″}$	
	Physical Parameters			
1	pH	8.5	8.5	6-9
2	Conductivity (us/cm)	776	514	1500
3	TDS (ppm)	384	256	1000
4	Temperature	27.4 ^{0}C	29.3^{0}C	< 30^{0}
5	Appearance	Not Clear	Cloudy	-
6	Odour	Yes	Yes	-
7	Turbidity (NTU)	18.7	4.1	75
	Chemical Parameters			
8	Ammonia (mg/l)	3.32	0.00	10
9	Iron (mg/l)	0.20	0.19	20
10	Sulphate (mg/l)	100	9	500
11	Nitrate (mg/l)	2.40	3.60	50
12	Phosphate(mg/l)	0.42	0.42	5
13	Total Hardness (mg/l)	342	496	-
14	Total Alkalinity (mg/l)	250	273.3	-
15	Chloride (mg/l)	345.73	214.10	600
16	Salinity (mg/l)	570.45	353.27	-
17	COD (mg/l)	320.0	37.14	250
18	BOD (mg/l)	45.9	4.16	50
	Heavy Metals			
19	Lead (mg/l)	0.254	-0.019	0.1
20	Zinc (mg/l)	0.258	0.282	5
21	Copper (mg/l)	0.114	0.187	0.1
22	Nickel (mg/l)	0.236	0.060	< 1
23	Cadmium (mg/l)	0.109	0.082	0.5

of 1500 (Table 2).The total dissolved solids (TDS) concentration recorded was 384 ppm and 256 ppm. The values were both within the FEPA effluent quality guideline value of 1000 ppm (Table 2). The temperature values recorded for both the raw and treated effluents were 27.4 ^{o}C and 29.3 ^{o}C respectively. The values are within the acceptable limits of FEPA (1991) guidelines values in Table 2. Temperature in water is a very vital parameter that controls dissolution of gasses such as carbon dioxide and oxygen (Omer, 2019). The amounts and levels of chemical reactions are also affected by temperature and therefore, affect biological activities. Substantial increase in temperature, up to 36 ^{o}C can lead to increase in micro-organism pollution. It also condenses the amount of water and also leads to increase in the amount to nitrification (Shmeis, 2018). The appearance of the raw and treated effluent samples from the pharmaceutical company was not clear enough, but turned cloudy after treatment.This shows substantial improvement in pollutant load after treatment before being discharged into the environment. The turbidity recorded was 18.7 NTU and 4.1 NTU. The turbidity concentration recorded from the pharmaceutical company for both raw and the treated effluents were both within the Federal Environment Protection Agency (FEPA) effluent quality guideline value of 75 NTU (Table 2).

3.4 Chemical Parameters

3.4.1 Ammonia, Iron (Fe), Sulphate, Nitrate–Nitrogen, Phosphate, Total Hardness, Total Alkalinity, Chemical Oxygen Demand (COD), and Biochemical Oxygen Demand (BOD)

The concentration of ammonia–nitrogen in the raw effluent samples of the pharmaceutical company was found to be 3.32mg/l and that of the treated effluent sample was 0.00 mg/l. All the samples tested are within the acceptable limit of FEPA effluent quality guideline value of 10 mg/l (Table 2). The concentration of iron (Fe) in the effluent samples of the pharmaceutical company and the treated effluent were found to be 0.20 mg/l and 0.19 mg/l. The study revealed that the iron concentration of both the raw and treated effluent samples was within the acceptable limit of FEPA effluent guideline value of 20 mg/l (Table 2). The concentration of sulphate in the effluent samples for both the raw and treated were found to be 100 mg/l and 9 mg/l. The sulphate concentrations recorded were all within the permissible limit of the Federal Environment Protection Agency (FEPA) effluent quality guideline value of 500 mg/l (Table 2). The concentration of nitrate in the effluent samples from the pharmaceutical company was found for raw to be 2.40 mg/l and in the treated effluent was 3.60. The values of the effluent sampled were within the permissible limit of EFPA effluent quality guideline value of 50 mg/l (Table 2). Nitrate, Phosphate and

Sulphate are vital parameters of river water showing the pollution status associated with anthropogenic load into the stream water (Ugwu & Wakawa, 2012; Adesuyi *et al.,* 2015; Hamid *et al.,* 2020; Isiuku & Enyoh, 2020).The concentration of phosphate in the raw effluent and treated samples from the pharmaceutical company were (0.42 mg/l and 0.42 mg/l). The phosphate concentrations recorded in the raw and treated effluent samples were below the FEPA acceptable limit of 5 mg/l, which is satisfactory (see Table 2). It was observed that a total hardness of 342 was recorded for the raw effluent and 496 for the treated effluent samples from the pharmaceutical company. A total alkalinity of 250 was recorded for the raw effluent and 273.3 for the treated effluent emanating from the pharmaceutical company. The chemical oxygen Demand (COD) concentrations of the raw effluent samples from the pharmaceutical company were found to be 320.0 mg/l and 37.14 mg/l. The results showed that the raw effluent samples do not comply with the specified limit of 250 mg/l as stipulated by Federal Environment Protection Agency (FEPA) guideline, while the treated effluent was below the acceptable limit of FEPA (See Table 2). The presence of high level of COD in the raw effluents is an indication of production of wide range of waste such as fat, organic and inorganic solids, salts and chemicals added in the processing and operation by human activities (Aniyikaiye *et al.,* 2019; Paśmionka *et al.,* 2022). So also, the high concentration may be as a result of simulated suspended solids from the surrounding. This shows that the discharge of wastewater along the river would contribute significantly to the organic pollution of the river. The biochemical oxygen demand (BOD) in the raw and treated effluent samples from the pharmaceutical company was found to be 45.9 mg/l and 4.16 mg/l. The BOD values observed were within the Federal Environment Protection Agency (FEPA) effluent guideline value of 50 mg/l as indicated in Table 2.

3.5 Heavy Metals

3.5.1 Lead (Pb), Zinc (Zn), Copper (Cu), Nikel (Ni), and Cadmium (Cd)

The concentrations of lead (Pb) in both the raw and the treated effluent samples taken from the pharmaceutical company were recorded as 0.078 mg/l and 0.019 mg/l respectively. The lead concentrations observed were within the acceptable limit of FEPA effluent quality guideline of less than 0.1 mg/l (see Table 2). The concentration of Zinc metal in the raw effluent samples from the pharmaceutical company in this present study was 0.258 mg/l and for the treated effluent was 0.282 mg/l. The Zinc concentrations recorded were all within the (FEPA) effluent quality guideline of 5 mg/l (Table 2). The concentration of copper metal in the raw effluent samples from the pharmaceutical company was 0.019 mg/l and that of the treated effluent was recorded as 0.045 mg/l. The copper concentrations recorded were all within the FEPA effluent quality guideline of less than 1 mg/l (Table2). The result presented in Table 2 above shows the concentration of Nickel metal in the raw effluent and treated samples taken from the pharmaceutical company as 0.236 mg/l and 0.060 mg/l. The Nickel values recorded were all within the acceptable limit of the FEPA effluent quality guideline of less than 1 mg/l. The cadmium concentration in the raw effluent and treated effluent samples from the pharmaceutical company were recorded as 0.109 mg/l and 0.082 mg/l respectively. The cadmium values recorded for both raw and treated effluent samples were all within the acceptable limit of the (FEPA) effluent quality guideline of less than 1 mg/l (Table 2).

3.6 Quality of Some Selected Water Sources around the Sampled Dump Sites

The results of physico-chemical and heavy metal analysis of water samples upstream and downstream of river/streams, close to dumpsites, boreholes, hand pumps, and hand dug wellsin the communities around the dumpsites were presented in Tables 3 and 4 and compared with the World Health Organisation (WHO)*, and the National Standard for Drinking Water Quality (NSDWQ, Nigeria) *.

3.7 Physico-Chemical Parameters

3.7.1 Physical Parameters - The pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Temperature, Appearance, and Turbidity

The pH values recorded in the receiving stream (upstream and downstream) ranged from 6.8 to 8.5 (Table 3 and4). The results were all within the acceptable limits of NSDWQ and WHO standards for drinking water guidelines, though a pH of 8.5 and 8.4 were recorded at Kuyi village upstream and downstream, which is slightly above the specified limit. Whereas, the results recorded for the boreholes sample ranged from 6.8 to 8.0, and for hand dug well samples was between 6.8 and 7.9 and are all within the acceptable limits of NSDWQ and the WHO standards for drinking water (Table 3 and 4). The state of pH in natural water primarily controls the geochemical processes like solubility, ion exchange, weathering, sorption, precipitation and buffering capacity (Ekwere *et al.,* 2023). The electrical conductivity in the receiving stream samples, and the results ranged from 110.4 μscm^{-1} to 284 μscm^{-1}, and all the boreholes are within the acceptable limits (270 μscm^{-1} to 507 μscm^{-1}) of the NSDWQ standards of 1000 μscm^{-1}, (Tables 3 and 4) with the exception of the borehole at the pharmaceutical company that recorded 1264 μscm^{-1} above the limits of the NSDWQ and WHO standards. Also, the hand dug wells samples results were 211 μscm^{-1} and 412 μscm^{-1}, and all the results were within the acceptable limits of the NSDWQ and WHO standards of drinking water of 1000 μscm^{-1} (Table 3 and 4). The total dissolved solids values recorded in the receiving stream ranged from 54.8 ppm to 144 ppm. The results were all within the acceptable limits of NSDWQ and WHO standards (Table 3 and4). Whereas, the boreholes sample results recorded between 135 ppm and 643 ppm, and the hand dug wells recorded 106 ppm and 207 ppm respectively. All the results were within the acceptable limits of NSDWQ and the WHO standards for drinking water (Table 3 and 4). The temperature values recorded in the receiving stream ranged from 22.44 ^{0}C to 29.10 ^{0}C. The results were all within the acceptable limits of NSDWQ and WHO standards. Except for temperatures recorded at Kuyi village upstream and downstream which are slightly above the acceptable limits (34.30 ^{0}C and 33.20 ^{0}C, Table 4). Whereas, the boreholes sample results recorded between 30.20 ^{0}Cand 30.90 ^{0}C respectively, which were slightly above the limits of NSDWQ and WHO standards 30 ^{0}C but acceptable and does not pose any problem. Temperature in water is a very vital parameter that controls dissolution of gasses, such as carbon dioxide and oxygen and also in mediating biological actions (Mugwanya *et al.,* 2022). The amounts and levels of chemical reactions are also affected by temperature. The substantial increase in temperature, up to 36 ^{0}Ccan lead to increase in micro-organism pollution. It also condenses the amount of water and can lead to increase in the amount to nitrification (Qu *et al.,* 2022).The appearance values recorded for streams, borehole, hand pumps and hand dug wells samples collected were clear, not clear, cloudy or brownish in nature (Table 3 and 4). High coloured water has significant effects on aquatic plants and algal growth. Light is very critical for the growth of aquatic plants and coloured water can limit the penetration of light. Thus, a high coloured body of water could not sustain aquatic life which can lead to long term impairment of the ecosystem (Sharmila *et al.,* 2018; Maltsev *et al.,* 2021). The result presented in Table 3 and 4 above shows the turbidity level in the receiving streams, bore holes and hand dug wells samples. For the receiving streams the result ranged from 2.8 NTU low to 99.9 NTU high. The turbidity level recorded during the study period in the receiving stream samples were all below the acceptable limits of NSDWQ and WHO standards, except for the upstream and downstream samples collected at Kuyi village which recorded 9.3 and 16.6 and the stream close to the dumpsite at AnguwanJatal Maitumbi with extremely high value of 99.9 NTU that were above the acceptable limits of 5 NTU. Also, all the boreholes and hand pump samples results were within the NSDWQ and WHO

Table 3: The quality of some selected water sources in the communities around the dump sites

S/N	Parameters	Dumpsite Downstream Korokpa	Upstream Korokpa	Hand Dug Well Korokpa (1)	Hand Dug Well Korokpa (2)	Angwan Jatal Matumbi Dumpsite Stream	Angwan Jatal Matumbi Hand Pump	NSDWQ (Nigeria)*	WHO*
		N09^{0} 31′20.2″ E006^{0} 34′49.8″	N09^{0} 31′17.8″ E006^{0} 34′43.9″	N09^{0} 31′31.1″ E006^{0} 34′44.1″	N09^{0} 31′26.4″ E006^{0} 34′52.9″	N09^{0} 31′40.8″ E006^{0} 36′07.3″	N09^{0} 37′58.0″ E006^{0} 35′53.4″		
	Physical parameters								
1	pH	7.8	6.8	7.9	6.8	7.2	6.8	6.5-8	6.5-8
2	Conductivity (us/cm)	182.1	284	412	211	240	507	1000	1000
3	TDS (ppm)	90.1	144	207	106	118	256	500	250
4	Temperature	22.9 ^{0}C	22.1 ^{0}C	26.9 ^{0}C	26.1 ^{0}C	29.1 ^{0}C	29.2 ^{0}C	30	30
5	Appearance	Cloudy	Not clear	Not clear	Not clear	Cloudy and brownish	Not clear	NA	NA
6	Odour	No	Yes	Yes	No	Yes	No	Unobjectionable	
7	Turbidity (NTU)	4.7	2.8	1.0	6.6	99.9	1.3	5	5
	Chemical parameters								
8	Ammonia (mg/l)	0.0	0.0	0.00	0.00	0.10	0.00	NA	0.1
9	Iron (mg/l)	0.12	0.06	0.00	0.01	0.80	0.03	0.3	
10	Sulphate (mg/l)	13	72	22	17	36	16	100	
11	Nitrate (mg/l)	3.00	3.20	2.04	3.80	2.10	10.7	50	50
12	Phosphate (mg/l)	0.42	0.0	0.88	0.59	0.68	0.00	100	NA
13	Total Hardness (mg/l)	72	58	220	94	110	176	150	
14	Total Alkalinity (mg/l)	192	128	145	140	156	323.3	500	500
15	Chloride (mg/l)	29.24	30.24	72.73	28.74	33.74	42.74	100	
16	Salinity (mg/l)	48.25	49.9	120.0	47.42	55.67	70.52	200	200
17	COD (mg/l)	18.70	21.40	20.35	25.10	28.14	14.23	40	40
18	BOD (mg/l)	2.86	2.86	2.57	2.90	22	1.78	10	10
	Heavy metals								
19	Lead (mg/l)	0.093	0.153	0.157	0.209	0.099	0.106		0.01
20	Zinc (mg/l)	0.243	0.695	0.246	0.243	0.243	0.132	3	
21	Copper (mg/l)	0.076	0.093	0.093	0.141	0.083	0.050	1	2
22	Nickel (mg/l)	-0.066	-0.009	0.033	0.056	-0.062	0.032	0.02	0.07
23	Cadmium (mg/l)	0.071	0.085	0.021	0.051	0.076	0.011	0.003	0.003

Table 4: The quality of some selected water sources in the communities around the dump sites

S/N	Parameters	Angwan Jatal Matumbi Borehole	DANA Pharm. Borehole	Kuyi Village Hand Pump	Kuyi Village Down stream	Kuyi Village Upstream	NSDWQ (Nigeria)*	WHO*
		N09^0 37’54.1$^{''}$ E006^0 35’53.4$^{''}$	N09^0 38’05.1$^{''}$ E006^0 34’58.5$^{''}$	N09^0 40’07.9$^{''}$ E006^0 26’16.1$^{''}$	N09^0 40’01.3$^{''}$ E006^0 26’13.6$^{''}$	N09^0 40’45.3$^{''}$ E006^0 25’52.8$^{''}$		
	Physical parameter							
1	Ph	8.0	7.1	7.2	8.4	8.5	6.5-8	6.5-8
2	Conductivity (us/cm)	428	1264	270	118.4	110.4	1000	1000
3	TDS (ppm)	215	643	135	59.2	54.8	500	250
4	Temperature	30.2 ^{0}C	30.9 ^{0}C	30.7 ^{0}C	33.2 ^{0}C	34.3 ^{0}C	30	30
5	Appearance	Clear	Clear	Clear	Not clear	Not clear	NA	NA
6	Odour	No	No	No	No	No	Unobjectionable	
7	Turbidity (NTU)	0.2	0.6	4.0	16.6	9.3	5	5
	Chemical parameters							
8	Ammonia (mg/l)	0.00	0.00	0.00	0.00	0.02	NA	0.1
9	Iron (mg/l)	0.00	0.03	0.17	0.12	0.01	0.3	
10	Sulphate (mg/l)	10	25	14	9	8	100	
12	Nitrate (mg/l)	3.70	2.50	1.62	3.40	2.70	50	50
13	Phosphate (mg/l)	0.57	0.92	0.28	0.55	0.00	NA	NA
14	Total Hardness (mg/l)	30	610	119	39	45	150	
15	Total Alkalinity (mg/l)	288	333.3	173	83	90	NA	NA
16	Chloride (mg/l)	35.24	237.43	26.74	19.24	18.24	250	
17	Salinity (mg/l)	58.14	391.75	44.12	31.75	20.10	NA	NA
18	COD (mg/l)	12.46	31.74	14.40	10.71	9.81	40	40
19	BOD (mg/l)	2.28	3.46	1.82	2.20	1.47	10	10
	Heavy metals							
20	Lead (mg/l)	-0.056	-0.013	-0.014	0.052	0.161		0.01
21	Zinc (mg/l)	0.247	0.243	0.247	0.266	0.251	3	
22	Copper (mg/l)	0.050	0.128	0.113	0.150	0.164	1	2
23	Nickel (mg/l)	0.077	0.040	0.102	0.148	0.011	0.02	0.07
24	Cadmium (mg/l)	0.055	0.095	0.044	0.038	0.031	0.003	0.003

standards of drinking water. For the hand dug wells, the turbidly recorded are all within the permissible limit of both NSDWQ and WHO. The high turbidity values recorded for streams may be due to soil erosion, presence of algae, or sediments stirred up from the stream beds. In streams, increased sediments and siltation can occur, which can harm the habitat of fish and other aquatic life. Excessive turbidity or cloudiness in drinking water is aesthetically unappealing (Davies-Colley & Smith, 2001; Bilotta & Brazier, 2008; Copes *et al.,* 2008). High turbidity can promote a regrowth of pathogens in water, leading to water borne disease outbreaks (Aulicino & Pastoni, 2004; Mann *et al.,* 2007).

3.7.2 Chemical Parameters – Ammonia, Iron (Fe), Sulphate, Nitrate-Nitrogen, Total Alkalinity, Chloride, Salinity, Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD)

The ammonia values recorded in the receiving stream, bore holes and hand dug wells samples ranged between 0 mg/l to 0.1 mg/l as represented in (Table 3 and 4). The results were all within the acceptable limit of NSDWQ and WHO standard of 0.1 mg/l. Ammonia gets into water most frequently as runoff in agricultural areas, where it is applied as fertilizer and it easily finds its way into the underground aquifer from animal feedlot runoff (Craswell, 2021; Zahoor & Mushtaq, 2023). Ammonia is a colourless, pungent gaseous compound of hydrogen and nitrogen that is highly soluble in water. It is a biologically active compound found in mist waters as a normal biological degradation product of nitrogenous organic compound (protein).The iron (Fe) values recorded in the receiving streams, borehole, hand pumps and hand dug well samples ranged from 0.00 mg/l to 0.20 mg/l. The concentration of iron (Fe) in all the samples collected were below the acceptable limit of NSDWQ and WHO standards except for the stream sample at Anguwan Maitumbi dumpsite that recorded 0.8 mg/l, which is above the acceptable limit of 0.3 mg/l and this might be attributable to leachates from the dumpsite (Table 3 and 4). Iron (Fe) in water has many effects on aquatic life, both good and bad. Iron (Fe) occurs naturally in water and it is also found as minerals in the soil, which is why groundwater contains the highest iron concentrations (Heikkinen *et al.,* 2022; Xia *et al.,*2022). Iron levels in water vary depending on several factors and can affect aquatic populations, behaviour and health (Rabajczyk & Namieśnik, 2014; Aziz *et al.,* 2023). Higher levels of iron in fish and aquatic plants also have negative effects on the people or creatures consuming them. Also, large amount of iron promotes growth of algae, which can block sunlight for other plants and can disrupt habitats and feeding practices (Gulati *et al.,* 2022; Dey *et al.,* 2024; Mustafa *et al.,* 2024).The sulphate values recorded in the receiving streams, bore holes, hand pumps and hand dug wells samples ranged from 8.0 mg/l to 72 mg/l (Table 3 and 4). The results were all within the acceptable limits of NSDWQ. The consumption of drinking water containing high amounts of sulphate may results in intestinal discomfort, diarrhea and consequently dehydration (Backer, 2000; Bashir *et al.,* 2012). High concentration of sulphate may interfere with the efficiency of chlorination in some water supplies (Clayton *et al.,* 2021; Ren & Ling, 2021). Sulphate is a natural occurring substance that contains sulphur and oxygen, and maybe leached from the soil and is commonly found in most water supplies (Backer, 2000; Moreno *et al.,* 2009; Torres-Martínez *et al.,* 2020).The concentrations of nitrate in the receiving stream, bore holes and hand dug wells samples, ranged from 1.6 mg/l to 10.7 mg/l (Table 3 and 4). The concentrations of nitrate during the study in the receiving stream samples were all within the acceptable limits of NSDWQ and WHO standards of 50 mg/l. Nitrate is composed of phosphate, the key ingredients in fertilizers but can also come from sewage water. Nitrate is potentially risky; its high concentration in water functions as a good pointer of chemically polluted water (Dike *et al.,* 2010). High concentration of nitrate has a harmful effect on living organism (Ward *et al.,* 2018; Grout *et al.,* 2023). Also, nitrate can pose great risk to public health by transformation to nitrosamines, which are carcinogenic in nature. Since nitrate and nitrite are nutrients, their presence in high concentrations can support the growth of algae in the water and subsequently damage the water quality (Ziarati *et al.,*2018; Karwowska & Kononiuk, 2020).The total Alkalinity in the streams, bore holes, hand pumps and hand dug wells samples analysed ranges between 83 mg/l to 333.3 mg/l, and all the samples' results showed that it is within the limit specified by NSDWQ and WHO standards of 500 mg/l (Table 3 and 4). Chloride concentration in the receiving streams, bore holes, hand pumps and hand dug wells samples ranges between 18.24 mg/l to 72.73 mg/l, and all the samples' results showed that it is within the limit specified by NSDWQ and WHO standards of 100 mg/l, with the exception of the bore hole at the pharmaceutical company which recorded 237.43 mg/l above the limit specified by NSDWQ and WHO standards of 100 mg/l (Table 3 and 4). The salinity contents in the streams, bore holes, hand pumps and hand dug wells samples collected and analysed ranged between 30.10 mg/l to 120 mg/l and are all within the limit specified by NSDWQ and WHO standards of 200 mg/l, with the exception of the bore hole at the pharmaceutical company which recorded 391.75 mg/l, above the limit specified by NSDWQ and WHO standards of 200 mg/l. The concentrations of chemical oxygen demand in the streams, bore holes, hand pumps and hand dug wells samples analysed, and ranged between 9.8 mg/l to 31.74 mg/l and are all within the limit specified by NSDWQ and WHO standards of 40 mg/l (Table 3 and 4). The high level of COD concentration is an indication of pollution of the streams and it might be due to a wide usage of chemical, organic fertilizer and discharge of effluent including sewerage by human. High concentration of COD is simulated by suspended solids from run-off from farm lands which reduce light penetration and as a result, affects plant production in the receiving water bodies by increasing turbidity and can also clog fish gills and other aquatic life (Jay Lehr *et al.,* 2005). The BOD values recorded in the streams, bore holes, hand pumps and hand dug wells samples analysed, ranged between 1.47 mg/l to 3.46 mg/l. The results were all within the acceptable limits of NSDWQ and the WHO standards for drinking water of 10 mg/l (Table 3 and 4).

3.8 Heavy Metals

3.8.1 Lead (Pb), Zinc (Zn), Copper (Cu), Nikel (Ni), and Cadmium (Cd)

The result presented in Table 3 and 4 shows the concentrations of lead in streams, bore holes, hand pumps and hand dug wells samples. The results ranged from -0.056 mg/l to 0.209 mg/l for streams, bore holes, hand pumps and hand dug wells. The concentrations of lead during the study in both the receiving stream and borehole samples were all above the acceptable limits of NSDWQ and WHO standards. The high concentration of lead (Pb) may be due to activities of human, which normally increase the concentration of lead on the surface of the earth, putting our own species at risk and poisoning plants and animal in the process (Kumar *et al.,* 2020; Levin *et al.,* 2021). The concentrations of Zinc in streams, bore holes, hand pumps and hand dug wells samples ranged from 0.132 mg/l to 0.695 mg/l (Table 3 and 4). The concentrations of zinc in streams, bore holes, hand pumps and hand dug wells samples during the study period were all within the acceptable limit of 3 mg/l of NSDWQ standard. Zinc can be introduced into water bodies naturally by erosion of minerals form rocks and soil, however since Zinc ores are only slightly soluble in water and Zinc is only dissolved at relatively low concentrations. High natural level of zinc in water is usually associated with higher concentrations of other metals such as lead and cadmium (Obasi & Akudinobi, 2020; Hussain *et al.,* 2022). The concentrations of copper in streams, bore holes, hand pumps and hand dug wells samples ranged from 0.050 mg/l to 0.187 mg/l (Table 3 and 4). The concentrations of copper in the receiving stream samples were all within the acceptable limits of 1 mg/l NSDWQ and 1 mg/l WHO standards. High copper concentration in water bodies is highly toxic to most fishes, invertebrates and aquatic plants than any other heavy metal except mercury. It reduces growth and rate of reproduction in plant and animal (Hossain & Rakkibu, 1999; Naz *et al.,* 2023). The concentrations of Nickel in streams, bore holes, hand pumps and hand dug wells samples ranged from -0.066 mg/l to 0.148 mg/l (Table 3 and 4). The concentrations of Nickel in both the receiving stream and borehole samples were all above the acceptable limits of NSDWQ and WHO standards, except for concentrations at AnguwanJatal Maitumbi bore hole with 0.077 mg/l and Kuyi village hand pump 0.102 mg/l and the downstream side 0.148 mg/l. However, the high level of Nickel concentration observed at the downstream side in the study area could be attributed to human activities on surface of the earth. Nickel is released into the environment by power plants, metal factories and waste incinerators. It is also used in fertilizers and enters groundwater from the runoff (Genchi *et al.,* 2020; El-Naggar *et al.,* 2021).The concentrations of cadmium in streams, bore holes, hand pumps and hand dug wells samples ranged from 0.011 mg/l to 0.109 mg/l for the streams, boreholes, hand pumps and hand dug wells samples analysed. The concentrations of cadmium were all not within the acceptable limits of 0.003 mg/l for NSDWQ and 0.003 mg/l for WHO drinking water quality standards (Table 3 and 4). Cadmium is generally present in the environment at low levels; human activity has greatly increased the levels of cadmium in environmental media relevant to population exposure (Khan *et al.,* 2022; Peana *et al.,* 2022). Human exposure occurs mainly from consumption of contaminated food, active and passive inhalation of tobacco smoke, and inhalation by workers in a range of industries (Shetty *et al.,* 2023). Cadmium exerts toxic effects on the kidney when it is in high level as well as the skeletal systems (Noll, 2003; Genchi *et al.,* 2020).

4. Conclusion

Solid and liquid wastes cause hostile impacts mostly in terms of environmental pollution such as air and water pollution, degradation of soil, and loss of biodiversity. The focus of the study was on three issues, which are location, the environment and public health. It was noted that both the nearby and far away residents were affected by the location of the dumpsite closer to their settlements. The further you move away from the dumpsite the impact is not as severe as those who are closer to the dumpsite, as residents located few meters from the dumpsite are most affected by bad smells from the dumpsite, mostly when wind is blowing towards their direction. The concentration of water quality parameters in streams, boreholes, hand pumps and hand dug wells in communities around the dump sites are all within the acceptable limits of NSDWQ and WHO standards for drinking water quality, except for the stream water sample which recorded high turbidity streams and this may be due to soil erosion, presence of algae, or sediments stirred up from the stream beds and also the concentrations of Nickel, Cadmium and Iron which were above the permissible limit. The physico-chemical and heavy metals parameters analysed for effluent samples from the industry are all within permissible limits of FEPA except for chloride and salinity that recorded higher values above the specified limits. From the findings of this research work, it was recommended that in order to improve the quality of surface and groundwater and to protect public health, particularly of the people who depends on them for their livelihood in the study area, additional studies should be carried in both the wet and dry seasons to ascertain the sternness of pollution tendencies and how it affects the plants and animals found within the area. Routine monitoring of surface and ground water and effluents quality should be carried out and this should always be done in conjunction with Federal Environmental Protection Agency (FEPA) and the Niger State Environmental Protection Board to make sure that obligatory standards and regulations are adhered to. There is urgent need to provide protective barriers at the waste disposal sites to prevent wind from scattering and transporting the wastes from the disposal sites to other locations and thereby polluting the surface waters within the area. Sound liners should be designed and constructed at all the proposed new and the old sites to serve as wastes containment berries or materials to prevent draining liquids from the wastes and enhancing the process of leachates within the area. The direct consumption of surface water should be prevented especially by the inhabitants of the downstream section as most of the result of the samples analysed do not comply with NSDWQ and WHO standard quality guidelines. Dump site close to the streams (i.e., Anguwan Jatal Maitumbi) should be cleared and immediately relocated, as it is suspected to be leaching into the streams within the area. Also, human activities at the downstream side of the study area should be controlled or completely avoided. Boreholes around the dump sites should be constantly tested in the laboratory, as the flaws in basement rocks could serve as conduit for the movement of contaminants to the boreholes. To provide good drinking water and protect public health disaster, government should introduce control measures such as providing good site for wastes dump faraway from drinking water sources, as well as monitoring and enforcing strict regulations concerning industrial effluent discharges to be treated before releasing into the environment

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Conflict of Interest

The authors declared no conflict of interest associated with this work

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APPENDIX I

Figure1: (a) Section of Korokpa dumpsite showing rock exposure after laterite had been excavated; (b) Interior parts of Korokpa dumpsite (see the depth of old excavation-2m depth); (c) A portion of Korokpa dumpsite (N09°31'26.5" E06° 34' 43.9") being used for farming (see beans plants in the background); (d) Panoramic view of of Korokpa dumpsite (see the pond and scattered settlement around the area)

APPENDIX II

Figure 2: (a) Local gold processing pits within the area (N09°31'31.1" E06°34'44"); (b) Area yet to be filled up within of Korokpa dumpsite (the seasonal pond provides water for cattle); (c) Stream marking the end of Korokpa dumpsite, aside from the buildings around, there is a poultry farm around with very offensive odour within this area; (d) Heaps of scavenged plastic materials from government approved dump site near Kuyi village (N09°37'41.8" E06°36' 07.3").