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Ogola-Emma Ebitimitula
Department of Chemistry, Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria

Egbere Ogbemudia Moses
Department of Chemistry, Ignatius Ajuru University of Education, Rumuolumini, Port Harcourt, Rivers State, Nigeria

Angaye S Samuel
Department of Chemistry, Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria

Corresponding Author:
Egbere Ogbemudia Moses
Department of Chemistry, Ignatius Ajuru University of Education, Rumuolumini, Port Harcourt, Rivers State, Nigeria

Quantitative analysis of physicochemical properties of surface water and soils around refuse dumpsite, Sagbama local government area, Bayelsa state, Nigeria

Ogola-Emma Ebitimitula, Egbere Ogbemudia Moses and Angaye S Samuel

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Abstract
Using standard analytical techniques including Atomic Absorption Spectroscopy. It was established how concentrated each surface water and dumpsite soil's physicochemical properties were. Eight sampling locations within the Sagbama Local Government Area of Bayelsa State, Nigeria, provided the samples. Surface water had the range of the following concentrations of physicochemical properties in (mg/l): 5.67 to 5.76 mg/l for pH, 15.22 to 16.55 mg/l for $NO_{3,}^{-}$ 715.62 to 817.66 mg/l for EC, 2.31 to 4.20 mg/l for TDS, 146.23 to 206.39 mg/l for SO_4^{2-} and 4.70 to 9.36 mg/l for TOC. The amount of each physicochemical parameter in the dumpsites oils varied, with pH ranging from 5.47 to 5.74 mg/kg, NO_3^- from 32.39 to 35.41 mg/kg, SO_4^{2-} from 15.26 to 16.31 mg/kg, EC from 667.9 to 752.2 mg/kg, and TOC from 4.70 to 9.36 mg/kg. These results were compared with other studies' findings and with the standards from the National Environmental Standard Regulation and Enforcement Agency (NESREA) and the World Health Organization (WHO). The average physicochemical properties of the surface water, except for pH, sulphate, and electrical conductivity, were below the permitted levels set by NESREA (2009) and WHO (2011). The average pH values in all the tested areas indicated that the surface water was slightly acidic. Apart from total organic carbon and electrical conductivity, the average physicochemical properties of the soil from the dumpsites were also lower than the WHO (2011) and NESREA (2009) acceptable values. Because of the extremely low concentrations of the heavy metals and physicochemical properties studied, this research project demonstrated that the environment is not at risk. It was suggested, among other things, that the dumpsites be placed under close observation and that the public be made aware of the harmful consequences that exposure to heavy metal poisoning in the soil can have on health. Also reducing all human activities that worsen surface water's metal pollution, we can protect both the aquatic habitats and the local population that depends on it for their livelihood.

Keywords: Quantitative, analysis, physicochemical properties, surface water, Sagbama

Introduction
Due to the nature of heavy metals, their bioaccumulation, and the toxicological issues they can create, the contamination of the aquatic environment by these substances is a global concern. Both natural and man-made activities introduce heavy metals into the aquatic environment, contaminating sediment and water to levels that will harm aquatic animals' and people's health. Heavy metal concentrations in aquatic media are naturally relatively low, therefore they do not pose a hazard to the environment. However, at very high and undesired levels, they may pose a risk to both humans and the environment.

Heavy metal-contaminated soils can be dangerous to human health in addition to being a serious issue for plant nutrition and the food chain. Monitoring the concentration, phase association, and mobility of metals in an environment with high human activity is crucial because protecting terrestrial and aquatic ecosystems from contamination due to anthropogenic activities is a global priority.

Like other metropolitan areas, Sagbama Local Government Area may use these contaminated sites for residential, commercial, recreational, or educational purposes in the future when demand for acceptable property for development outpaces supply.

The overall health and well-being of the residents may be at risk if these areas are developed and used without being cleaned up. It is crucial to keep an eye on the concentrations of heavy metals in the soil since this information is crucial for understanding the origins, distribution, and level of pollution of these metals. Hence this study seeks to ascertain the concentrations of physicochemical properties of surface water and soils around dumpsites in Sagbama Local Government Area, Bayelsa State.

Aim and Objectives of the study: The study aims to assess the concentrations of physicochemical properties of surface water and soils around the dumpsites.

The specific objectives of the study are to:

1. Determine some physicochemical properties such as pH, total organic carbon (TOC), total dissolved solid (TDS) nitrates, sulphates and electrical conductivity of surface water samples.
2. Evaluate some physicochemical properties such as pH, total organic carbon (TOC), nitrates, sulphates and electrical conductivity of soil samples.

Materials and Methods

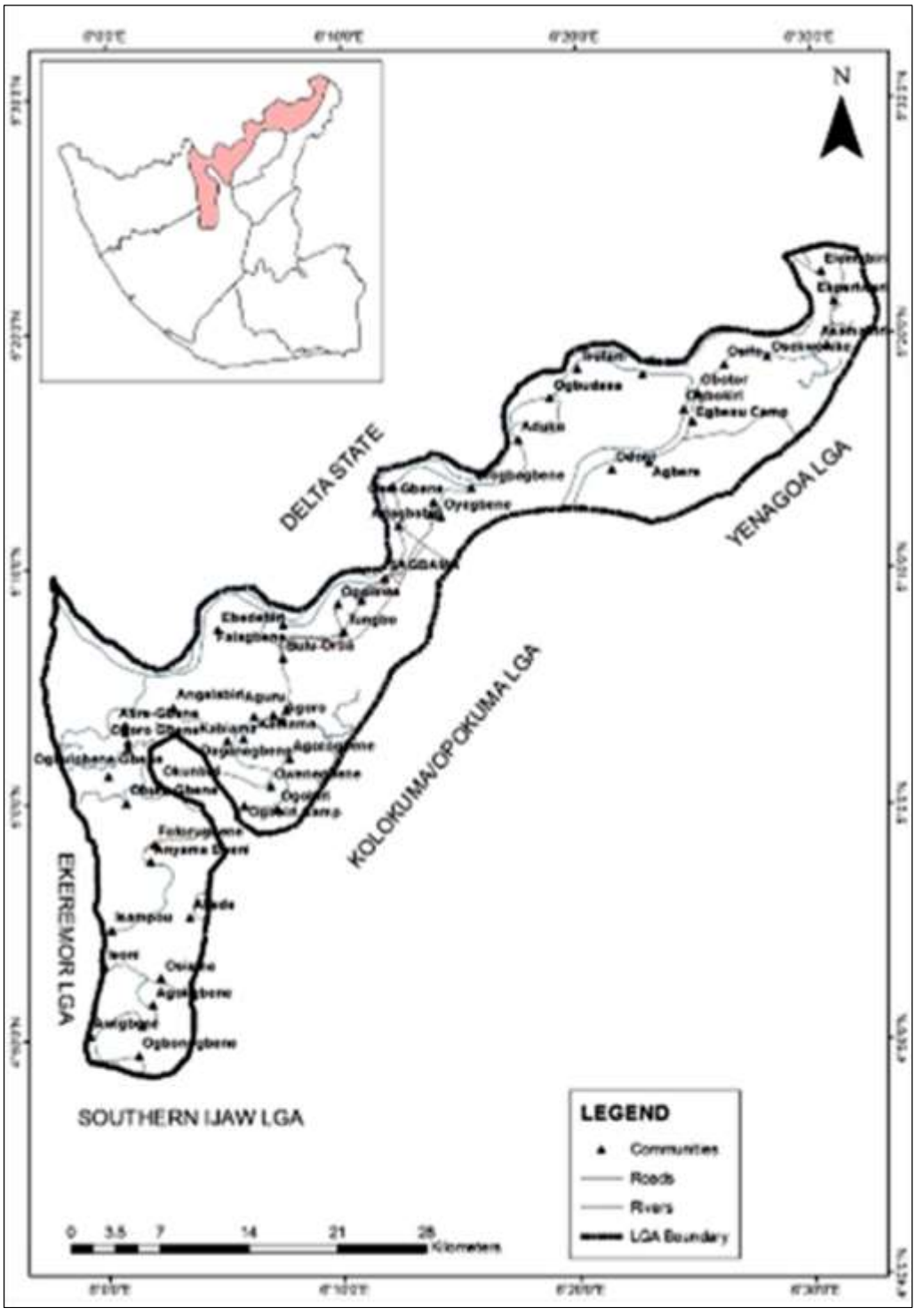

Fig 1: Map of the study area showing sample collection sites

The LGA spans an area measuring 945 square kilometres and with a temperature averaging 25 degrees Celsius. The Local Government Area is covered with water with the LGA hosting the Focardos River and other tributaries of the River Niger. Sagbama LGA is host to part of the Bayelsa National Forest with the area being heavily forested. The LGA experience high humidity and heavy rainfall for major part of the year and have two major seasons, the rainy and dry seasons which are characteristics of the equatorial climate. The LGA experience an annual rainfall amounting to 2673.8 mm and a mean temperature of 32.8 ℃ and is also marked by a tropical equatorial climate.

Eight (8) sampling locations provided the water samples. That is from Sagbama, Adagbabiri, Tungbo, and Toru-Orua, two (2) locations each. In each municipality, water samples were taken from both banks of the Forcados River. The collected surface water samples were put into previously cleaned, sealed, labelled plastic bottles before being taken to the laboratory for preparation and analysis using atomic absorption spectroscopy.

Eight (8) sites were used to gather the soil samples. In other words, two locations from each of Adagbabiri, Tungbo, Sagbama, and Toru-Orua. The samples were gathered in the vicinity of each town's dumpsites. After being gathered, the soil samples were tagged, put in sterile polythene bags, and transported to the laboratory for atomic absorption spectroscopic analysis. After thoroughly mixing and acidifying the 100 cm^3 water sample, it was put into a conical flask to be digested. The sample under the fume hood received a volume of 5 ml of HNO_3. Before precipitation happens, It was brought to a gentle boil and then reduced in volume to the smallest possible amount (about 1-2 millilitres) on a hot plate. The heating procedure was continued until complete digestion produced a translucent, light-colored solution. The substance was filtered, and the filtrate was then transferred to a 100-volumetric flask and diluted to the 50-milliliter mark. This solution was taken to the lab for analysis of its physicochemical properties.

A 0.5 gramme sample of soil was carefully put into a digestive tube. 15 millilitres of aqua regia (three parts hydrochloric acid to one part trioxonitrate (iv) acid) were added. The liquid was briskly spun to get the sample wet, and it was then stored overnight. The following day, the tube was heated to 50 °C for 30 minutes at a time. After that, it was heated to 120 °C for two hours. According to Radojevic and Bashkin (1999), the digest was cooled, filtered through filter paper, and then increased to 25 millilitres using 0.25 mol/L trioxonitrate (iv) acid. After that, the sample solution was examined using conventional analytical techniques to determine its physicochemical, properties.

Results

Table 1: Mean of concentrations of physicochemical properties of surface water

Sample properties (mg/l)	SAGBAMA	ADAGBABIRI	TUNGBO	TORU-ORUA	WHO (2011)	NESREA (2009)
pH	5.73±0.01	5.75±0.01	5.68±0.01	5.67±0.00	6.5-8.5	6.0-8.5
Nitrate	15.24±0.01	16.55±0.01	15.27±0.08	16.54±0.00	200	500
Sulphate	146.23±0.00	154.30±0.00	156.48±0.08	205.84±0.77	0.05	<0.05
EC	815.91±0.71	720.63±7.08	717.28±0.79	817.59±0.09	600	400
TDS	2.31±0.01	3.86±0.01	4.18±0.03	2.41±0.01	2000	2100
TOC	198.06±0.63	196.77±0.63	198.29±0.12	198.27±0.02	-	-

***Source*:** Researcher's field data, (2024).

Table 1 shows summary of descriptive statistics of physicochemical properties of surface water in the sampling locations. The result show that pH has a mean and standard deviation values of 5.73±0.01 in Sagbama, 5.75±0.01 in Adagbabiri, 5.67±0.00 in Tungbo, 5.67±0.00 in Toru-Orua and 2.69±0.00 as the control. The result also shows that nitrates has a mean and standard deviation values of 15.24±0.01 in Sagbama, 16.55±0.01 in Adagbabiri, 15.27±0.08 in Tungbo, 16.54±0.00 in Toru-Orua and 3.47±0.00 as the control. The result further shows that Sulphates has mean and standard deviation values of 146.23±0.00 in Sagbama, 154.30±0.00 in Adagbabiri, 156.48±0.08 in Tungbo, 205.84±0.77 in Toru-Orua and 2.98±0.00 as the control. The result indicated that EC (electrical conductivity) recorded a mean and standard deviation values of 815.91±0.71 in Sagbama, 720.63±7.08 in Adagbabiri, 717.28±0.79 in Tungbo, 817.59±0.09 in Toru-Orua and 2.77±0.00 as the control. The result also outlined that TDS (total dissolved solids) has a mean and standard deviation values of 2.31±0.01 in Sagbama, 3.86±0.01 in Adagbabiri, 4.18±0.03 in Tungbo, 2.41±0.01 in 198.27±0.02 and 2.68±0.00 as the control. Finally, the result shows that TOC (total organic carbon) had a mean and standard deviation values of 198.06±0.63 in Sagbama, 196.77±0.63 in Adagbabiri, 198.29±0.12 in Tungbo, 198.27±0.02 in Toru-Orua and 3.53±0.00 as the control. The result further shows that lead has a mean value of 2.58±0.71 in Sagbama, 4.76±0.01 in Adagbabiri, 2.25±0.00 Tungbo, 2.75±0.02 in Toru-Orua and 3.09±0.00 as the control. The result also shows that chromium has a mean value of 6.09±0.01 in Sagbama, 6.52±0.52 in Adagbabiri, 5.89±0.00 in Tungbo, 5.78±0.01 in Toru-Orua and 2.57±0.00 as the control. The result indicated that cadmium has a mean value of 2.17±0.00 in Sagbama, 2.74±0.01 in Adagbabiri, 1.04±0.01 in Tungbo 1.98±0.02 in Toru-Orua and 1.41±0.00 as the control. The result also shows that copper has a mean value of 3.80±0.07 in Sagbama, 2.26±0.01 in Adagbabiri, 3.87±0.00 in Tungbo, 2.63±0.51 in Toru-Orua and 2.56±0.00 as the control. The result further outlined that zinc has a mean value of 5.89±0.01 in Sagbama, 4.09±0.00 in Adagbabiri, 4.90±0.05 in Tungbo, 6.15±0.00 in Toru-Orua and 2.69±0.00 as the control. The result indicated that nickel has a mean value of 7.04±0.01 in Sagbama, 6.08±0.01 in Adagbabiri, 6.83±0.09 in Tungbo, 7.93±0.08 in Toru-Orua and 1.51±0.00 as the control. The statistical analysis shows a p-value less than 0.05 therefore there is a significant difference in the concentrations of heavy metals in surface water among sampling locations.

Table 2: Summary of Pearson correlation of physicochemical parameters (pH, electrical conductivity (EC), nitrate, sulphate, total dissolved solid (TDS) and total organic carbon (TOC)) of surface water from various sampling locations

Correlations							
		pH	Nitrate	Sulphate	EC	TDS	TOC
pH	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	10					
Nitrate	Pearson Correlation	.993**	1				
	Sig. (2-tailed)	.000					
	N	10	10				
Sulphate	Pearson Correlation	.946**	.967**	1			
	Sig. (2-tailed)	.000	.000				
	N	10	10	10			
EC	Pearson Correlation	.989**	.983**	.962**	1		
	Sig. (2-tailed)	.000	.000	.000			
	N	10	10	10	10		
TDS	Pearson Correlation	.263	.255	.133	.124	1	
	Sig. (2-tailed)	.463	.476	.714	.733		
	N	10	10	10	10	10	
TOC	Pearson Correlation	.999**	.993**	.952**	.990**	.259	1
	Sig. (2-tailed)	.000	.000	.000	.000	.469	
	N	10	10	10	10	10	10

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2 shows the statistical analysis of Pearson correlation for physicochemical parameters of surface water in Sagbama, Adagbabiri, Tungbo and Toru-Orua sampling locations. The result shows that the physicochemical parameters such as pH, Nitrate, Sulphate, EC, TDS and TOC has a positive correlation. The sig. (2-tailed) indicated that there is no significant relationship between TDS and pH, Nitrate, Sulphate, EC and TOC. The result finally shows that there is a significant relationship between pH, Nitrate, Sulphate, EC and TOC.

Table 3: Mean of concentrations of physicochemical properties in soils of Refuse Dumpsites

Sample properties (mg/kg)	SAGBAMA	ADAGBABIRI	TUNGBO	TORU-ORUA	WHO (2011)	NESREA (2009)
pH	5.73±0.01	5.64±0.06	5.48±0.01	5.68±0.01	85	164
EC	744.25±2.05	6.67±0.36	746.85±7.57	6.93±0.08	100	100
TOC	9.35±0.01	4.83±0.19	9.04±0.02	5.90±0.07	36	100
Nitrate	34.53±0.02	32.45±0.09	32.96±0.58	35.33±0.12	0.8	3
Sulphate	16.31±0.00	15.28±0.03	15.54±0.01	16.22±0.01	-	421

***Source*:** Researcher's field data, (2024).

Table 3 shows summary of descriptive statistics for physicochemical parameters of soil in Sagbama, Adagbabiri, Tungbo and Toru-Orua sampling locations. The result shows that PH has a mean value of 5.73±0.01 in Sagbama, 5.64±0.06 in Adagbabiri, 5.48±0.01 in Tungbo and 5.68±0.01 in Toru-Orua. The result also shows that EC (electrical conductivity) has a mean value of 744.25±2.05 in Sagbama, 6.67±0.36 in Adagbabiri, 746.85±7.57 in Tungbo and 6.93±0.08 in Toru-Orua. The result further indicated that TOC (total organic carbon) has a mean value of 9.35±0.01 in Sagbama, 4.83±0.19 in Adagbabiri, 9.04±0.02 in Tungbo and 5.90±0.07 in Toru-Orua. The result also outlined that Nitrate has a mean value of 34.53±0.02 in Sagbama, 32.45±0.09 in Adagbabiri, 32.96±0.58in Tungbo and 35.33±0.12 in Toru-Orua. The result also shows that Sulphate has a mean value of 16.31±0.00 in Sagbama, 15.28±0.03 in Adagbabiri, 15.54±0.01 in Tungbo and 16.22±0.01 in Toru-Orua. The result finally shows that the control has a mean value of 3.68±0.00 in Sagbama, 2.68±0.00 in Adagbabiri, 2.53±0.00 in Tungbo and 2.77±0.00 in Toru-Orua. The statistical analysis show a p-value less than 0.05 therefore there is a significant difference in the concentrations of physicochemical parameters in soil among sampling locations.

Table 4: Summary of Pearson correlation of physicochemical parameters pH, electrical conductivity (EC), nitrate, sulphate, total dissolved solid (TDS) and total organic carbon (TOC)) of soil in Sagbama, Adagbabiri, Tungbo and Toru-Orua sampling locations

Correlations						
		pH	Nitrate	Sulphates	EC	TOC
pH	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	8				
Nitrates	Pearson Correlation	.566	1			
	Sig. (2-tailed)	.144				
	N	8	8			
Sulphates	Pearson Correlation	.624	.932**	1		
	Sig. (2-tailed)	.098	.001			
	N	8	8	8		
EC	Pearson Correlation	-.271	-.063	.198	1	

	Sig. (2-tailed)	.517	.882	.638		
	N	8	8	8	8	
TOC	Pearson Correlation	-.191	.135	.377	.979**	1
	Sig. (2-tailed)	.651	.750	.357	.000	
	N	8	8	8	8	8

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4. Shows the statistical analysis of Pearson correlation for physicochemical parameters of soil in Sagbama, Adagbabiri, Tungbo and Toru-Orua sampling locations. The results shows that Pb has a positive correlation with all the physicochemical parameters. The sig. (2-tailed) shows that there is a significant difference in the correlation except EC. The result also shows that Cr has a positive correlation with all the physicochemical parameters except pH. The sig. (2-tailed) also shows that there is no significant difference in the correlation. The result further indicated that Cu has a positive correlation with all the physicochemical parameters. The sig.(2-tailed) also shows that there is a significant difference in the correlation with Cu and $N0_3^-$ and $S0_4^-$ and no significant difference with pH, EC and TOC. The results further outlined that Cd has a positive correlation with all the physicochemical parameters except pH. The sig. (2-tailed) also shows that there is no significant difference in the correlation with all physicochemical parameters. Moreover, the result also shows that Zn has a positive correlation with $N0_3^-$ and $S0_4^-$ and a negative correlation with pH, EC and TOC. The sig. (2-tailed) also shows that there is no significant difference in the correlation with all physicochemical parameters. The result also shows that Ni has a negative correlation with all physicochemical parameters except $N0_3^-$. The sig. (2-tailed) also shows that there is no significant difference in the correlation with all physicochemical parameters.

Discussion

Physicochemical properties of surface water

pH: The majority of chemical and biological reactions in water are impacted by its pH. It is among the most significant environmental elements influencing the distribution of species in aquatic environments. Surface water systems typically have a pH between 6.5 and 8.5, while ground water systems typically have a pH between 6 and 8.5 (WHO, 2011) [24]. The water in this sample had a pH of 5.58±0.01, which indicates that it is slightly acidic. The pH readings varied from 5.67 to 5.76. The Adagbabiri 1 and Tungbo 2 sampling locations had the greatest and lowest pH values, respectively. The surface waters that were sampled had a pH that was below the 6.5 to 8.5 range that the World Health Organisation (2011) [24] recommended. At certain pH levels, certain substances are more harmful to aquatic life; for example, the toxicity of nickel cyanide rises as pH falls.

Nitrates

Nitrate is one kind of nitrogen. It can pass quickly through soil to reach the water table and dissolve easily in water. Groundwater, streams, rivers, and surface waters are frequently high in nitrate, which promotes the growth of algae and plants. The average nitrate concentration in the sampled area was 16.55±0.01 mg/L, with a range of 15.22 to 16.56 mg/l. Adagbabiri 2 and Sagbama 1 sampling locations had the highest and lowest nitrate concentrations, respectively. Table 4.5 indicates that these values are below the allowable limits set by the World Health Organisation (2011) [24] and the National Environmental Standard and Regulations Enforcement Agency (2009). The activities of both humans and the environment around the Forcados River and the dumpsites at the analysed locations are to blame for the nitrate levels found in the surface water samples.

Electrical conductivity

The study's electrical conductivity readings had a mean of 817.59 ±717.29 µs/cm and ranged from 816.40 to 715.62 µs/cm. The sampling locations Tungbo 2 and Adagbabiri 1 showed the highest and lowest EC, respectively. The World Health Organisation (2011) [24] and the National Environmental Standard Enforcement Agency (2009) have set allowable limits of 600 and 400 µs/cm, respectively, which these values exceed. These high EC values indicate that there is a notable concentration of ionizable compounds or trace metal ions in the surface water.

Sulphates

Sulphates are oxides of sulphur. They are found at very high concentration in many groundwater and surface water system. The sulphates values in sampled locations ranged from 146.23 to 206.39 mg/L with a mean values of 156.48±0.08mg/L. Sagbama 1 sample location and Tungbo 2 sampling location had the lowest and highest sulphates readings, respectively. These concentrations fall within the 500 mg/l permissible limits set by the National Environmental Standard and Regulations Enforcement Agency (NESREA), (2009). These sulphate levels could be the consequence of human and environmental activity.

Total dissolved solids

Extremely high TDS values can render surface water unsafe for irrigation and drinking by increasing its salt content. Total dissolved solids in the surface water samples ranged from 2.30 to 4.20 mg/L, with a mean value of 2.41±0.01 mg/l. The sampling locations with the lowest and highest TDS values were Sagbama 2 and Toru-Orua 1. The TDS measurements are below the permissible limits set by NESREA (2009) and WHO (2011) [24]. These low TDS results suggest that anthropogenic activity in the Forcados River is really little.

Total organic carbon

The measure of total organic carbon (TOC) indicates the level of contaminants or organic molecules present in surface water. The measure of TOC in water enables organizations know whether the water is safe for their specific needs. The TOC in the surface water samples in this study ranged from 197.21 to 198.50 mg/L with a mean value of 198.06±0.63 mg/l. The highest and lowest TOC values were observed in Sagbama 1 sampling location and Adagbabiri 1 sampling location. The high values of TOC in the sampled surface water indicates high level of contaminants or organic molecules present in the water of River Forcados, hence it may be unsafe for human consumption but safe for irrigation purposes.

Physicochemical properties of dumpsite soils

pH: Soil pH is a major factor influencing the availability of element in soil. It is well known that metal concentrations in

soil solution and consequently leaching can be much enhanced in soils with low pH and/ or redox potential. Most metal in the pH range of 6.0 – 9.0 are not always in the free form. The pH of this study ranged from 5.47 to 5.74mg /kg with a mean value of 5.73±0.0i. The highest and lowest pH values were obtained at Sagbama 1 and Tungbo1 sampling locations respectively. The pH of the soil samples in this study are slightly acidic, they were lower than the World Health Organization, (2011) [24] and National Environmental Standard and Regulation Enforcement Agency, (2009) set value of 6.5 to 8.5 and 6.0 to8.5. The soil pH obtained in this study were similar to the range of 5.9 -6.2 reported in soils of municipal waste dumpsites at Obafemi Awolowo University, Ile-Ife, 5.5 -6.4 reported in soils of dumpsites in Port Harcourt municipal and environs.

Electrical Conductivity

The electrical conductivity of the dump site soils in this study ranged from 6.419 to 752.2 µs/cm with a mean value of 746.85±7.57 µs/cm. The highest and lowest EC were observed at Tungbo 2 and Toru-Orua 2 sampling locations. The values of EC observed in this study are comparable to those reported by Akpoveta *et al*.; (2010) at 165-201 µs/cm, Osakwe, (2010) EC values ranging from 202-478 µs/cm and Amadi, (2010) EC values ranging from 380.0 - 198 µs/cm. The high conductivity values obtained in this study might be due to the presence of scraps in these dumpsites. The implication of these high values of EC is that there is significant presence of trace metal and ionizable materials in the soil.

Total Organic Carbon

The study's soil samples had total organic carbon (TOC) ranging from 4.696 to 9.357 mg/kg, with an average of 7.28 ± 0.01 mg/kg. The TOC levels in these soil samples showed a consistent trend. The sampling locations Sagbama 2 and Adagbabiri 2 showed the highest and lowest TOC values. The TOC values found in this study were more than those found in studies by Ogbonna *et al*. (2009), Ubuoh *et al*. (2012), and Osakwe (2014), which reported values of 0.08-3.41, 0.85-6.04, and 29.6-77.8 for TOC, respectively. Although soil organic carbon is not necessary for plant growth, the amount of organic matter in a soil affects several chemical and physical processes and is a key sign of the soil's suitability as a rooting medium.

Nitrates

The average nitrate level in the soil samples used for the investigation was 33.82 ± 0.12 mg/kg, with a range of 32.385–35.412 mg/kg. The highest and lowest NO3-values were obtained from the Toru-Orua 1 and Adagbabiri 2 sampling locations. The nitrate levels were within the permissible ranges of NESREA (2009) and WHO (2011), which are 45 and 20 mg/kg. The nitrate readings in this investigation were greater than those reported by Ogboru and Ekpete (2013), with a mean concentration of 2.103± 1.953 mg/kg.

Sulphates

The study's soil samples had sulphate concentrations ranging from 15.259 to 16.306, with mean values of 15.84 ± 0.01 mg/kg. The sampling locations Sagbama 2 and Adagbabiri 1 showed the greatest and lowest amounts, respectively. The study's sulphate concentrations fell between the WHO (2011) and NESREA (2009) defined standards of 200 and 500 mg/kg. The SO42-concentration in this study is more than the 7.27 ± 1.997 mg/kg mean value reported by Ogboru and Ekpete in 2021.

Conclusion

The concentrations of physicochemical properties of surface water and dumpsite soil in Sagbama local government area, Bayelsa State were carried out. The results indicated that the average physicochemical properties of the surface water were lower than the WHO, (2011) [24] and NESREA, (2009) permissible values except pH, sulphate, and electrical conductivity. The surface water was found to be mildly acidic based on the average pH values across all sampled locations. The soil from the dumpsites had average physicochemical properties that were lower than the WHO, (2011) [24] and NESREA, (2009) permissible values except electrical conuctivity and total organic carbon. This research work indicated that the surface water was unsafe for drinking, but the environment was not at risk because the physicochemical properties and the heavy metals studied had very low concentrations.

Recommendation

It was suggested amongst others that the dumpsites should be put under strict supervision and public awareness made on negative effects to health by the exposure to heavy metal contaminations in the soil. Pipe-born water and other sources of water should be provided for the people of Sagbama LGA. Also the surface water should be safeguarded for aquatic habitats and people living in the area who depend on it for their livelihood by curbing all anthropogenic activities that heighten its metal pollution.

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