Broad-Based Assessment Of Water Pollution Level And Land Degradation At The Vicinity Of Ibeno Beach In Akwa Ibom State, Nigeria.

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ABSTRACT

Ibeno Beach in Akwa Ibom State faces alarming environmental challenges with potential risks on human health and the environment. Integrated approach involving classical, instrumental and space-based methods were employed to conduct rigorous heavy metal and physicochemical analyses of water, soil and plant samples to determine the extent of pollution. A total of 10 water, 10 plant (Beach morning glory: Ipomoea pes-caprae), and 20 soil samples were collected at various locations and coordinates taken. Multi-parameter analysis was conducted both in situ and in the laboratory. Physicochemical analysis of the water parameters revealed elevated levels of salt, chloride, TDS, and turbidity. Overall, the pH of samples varied significantly, and the electrical conductivity of the water samples were relatively high. Heavy metal analysis using Agilent 720 ES ICP-OES revealed moderate levels of Pb, Ni and Cr with range in water (0.01-0.04; 0.01-0.07; 0.01) mg/L, soil (0.04-51.59; 0.01-5.18; 0.01-9.69) mg/kg, and plant (1.48-6.19; 2.49-20.52; 0.73-13) mg/kg, respectively. Geospatial analysis using hyperspectral Landsat 8 sensor revealed a general landmass and feature loss indicating degradation. Statistical analysis using a one-way ANOVA at 95% confidence level revealed no significant difference in the heavy metal levels in most of the samples.

Key words: Broad-based, Pollution, Degradation, Assessment, Space Technology, Ibeno Beach

INTRODUCTION

Environmental pollution and land degradation are two phenomena that have impacted negatively on the earth's ecosystem over the years. Pollution is the introduction of harmful substances or energies into the natural environment, causing adverse changes[1]. The United States Environmental Protection Agency[2] defined pollution as any substances in water, soil, or air that degrade the natural quality of the environment, offend the senses of sight, taste, or smell, or cause a health hazard. These pollutants can manifest as solids, liquids, gases, or various forms of energy like radioactivity, heat, sound, or light. Pollution, whether arising from external or naturally occurring sources, has profound consequences on human health, ecosystems, and socio-economic systems[3]. In 2019, pollution claimed the lives of nine million people globally, representing one in every six deaths, a figure unchanged since 2015[1]. This underscores the urgency of addressing pollution's far-reaching impact.

Water pollution is the deterioration of water quality in many aquatic ecosystems, such as rivers, lakes, streams, and groundwater[4]. Water contaminants cover diverse substances, including heavy metals, persistent organic pollutants (POPs), sediments, pathogenic bacteria, and viruses, which give rise to significant health hazards[5,6,7]. In contrast, land pollution refers to the deposition of solid or liquid waste materials on land or underground, resulting in the contamination of soil and groundwater, posing risks to public health, and causing visually unappealing conditions[8]. Plant pollution is the contamination or deterioration of plant quality or health as a result of intake of toxic or injurious substances from the environment. Beach Pollution is the infiltration of a beach with any harmful substances that contaminates the coasts ranging from plastic, feces, trash, and litter to sewage, pesticides, and oil[6]. A polluted beach is a public health risk[9].

Land degradation is a reduction in the biological and economic productivity of terrestrial ecosystems, including soils, water, vegetation, other biota, and the ecological, biogeochemical and hydrological processes that operate therein; the loss of life-supporting land resource through soil erosion, desertification, salinization, acidification, etc.[10, 11] It is the persistent reduction of the production capacity of a land due to various human activities and natural processes, which may be manifested through any combination of several interrelated processes such soil erosion, deterioration of soil nutrients, loss of biodiversity, deforestation or declining vegetative health[12,13,14]. The study conducted by Iruoma[15] revealed the alarming situation of oil spills that result in the pollution of waterways and severe negative impacts on the livelihoods of communities in Akwa Ibom State and other States in the Niger Delta Region, Nigeria. [16]In his study, Babatunde asserted that the extensive exploration and exploitation of oil and gas resources has polluted the environment in Akwa Ibom State. According to a United Nations Report[17,18] human activities have degraded 40% of land on Earth. Many ecosystems still remain adversely affected by current land use practices and ever-growing demands for coastal land from urbanization and development[19].

Heavy Metal pollutants are prevalent in most polluted or contaminated environment[19]. Heavy Metal contamination of an area can be monitored and analyzed spectroscopically and geospatially. Several methods have been developed and applied in the determination of heavy metals in environmental and biological samples. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), and Inductively Coupled Atomic Plasma Optical Emission Spectroscopy (ICP-OES) are more often used in this area due to their advantages of simultaneous detection of multiple elements, short analysis time, high throughput and less sample consumption[21]. Space technology is a potent, efficient, cost-effective and reliable tool for environmental monitoring, mapping and analysis. Space technology, when integrated with conventional methods, enhances real-time monitoring of environmental changes and disasters[22,23].

MATERIALS AND METHODS

Description of the Study Area

Akwa Ibom is one of the 36 States in Nigeria, located in the South-South Geopolitical Zone, between Latitudes 4°32’ and 5°33’ North and Longitudes 7°35’ and 8°25’ East; is situated in the humid tropical region of the eastern Niger Delta[24]. The State is bordered on the east by Cross River State, on the west by Rivers State and Abia State, and on the south by the Atlantic Ocean. Akwa Ibom State is blessed with abundant human and natural Resources. The Niger Delta is a low-lying coastal region mostly greater than 3 m above sea level. The annual precipitation typically varies between 2000 mm and 4000 mm or even more (4500 mm) with relative humidity above 70%[24]. The Niger Delta is a vast low-lying region through which the waters of the Niger River drain into the Gulf of Guinea. The Niger Delta Region is situated on the Gulf of Guinea in the southern part of Nigeria.

Ibeno is located in Akwa Ibom State in the Niger Delta Region of Nigeria. Ibeno town lies in the Mangrove Forest Belt, on the eastern side of the Kwa Ibo River, about 3 kilometres (1.9 mi) from the river mouth. It is one of the largest fishing settlements on the Nigerian coast, bounded to the west by Eastern Obolo Local Government Area, to the north by Onna, Esit Eket and Eket Local Government Areas, and to the south by the Atlantic Ocean. The Headquarters of Ibeno Local Government Area is Upenekang. Ibeno Local Government Area has a population of about 75,380 people as at 2006 Census. The main economic activities in the area include: fishing, farming, trading, and artisanship, among others. The presence of oil exploration activities by ExxonMobil and other service companies influence activities both upstream and downstream. Ibeno Beach is one of the beaches on the Atlantic Ocean shoreline, which attracts both local and international tourists. The natural scenery of visual spectacle blends with the sound of the splashing waves, and provides endless natural environment for sport, boating and recreation. The area has a tropical climate with dry and wet seasons.

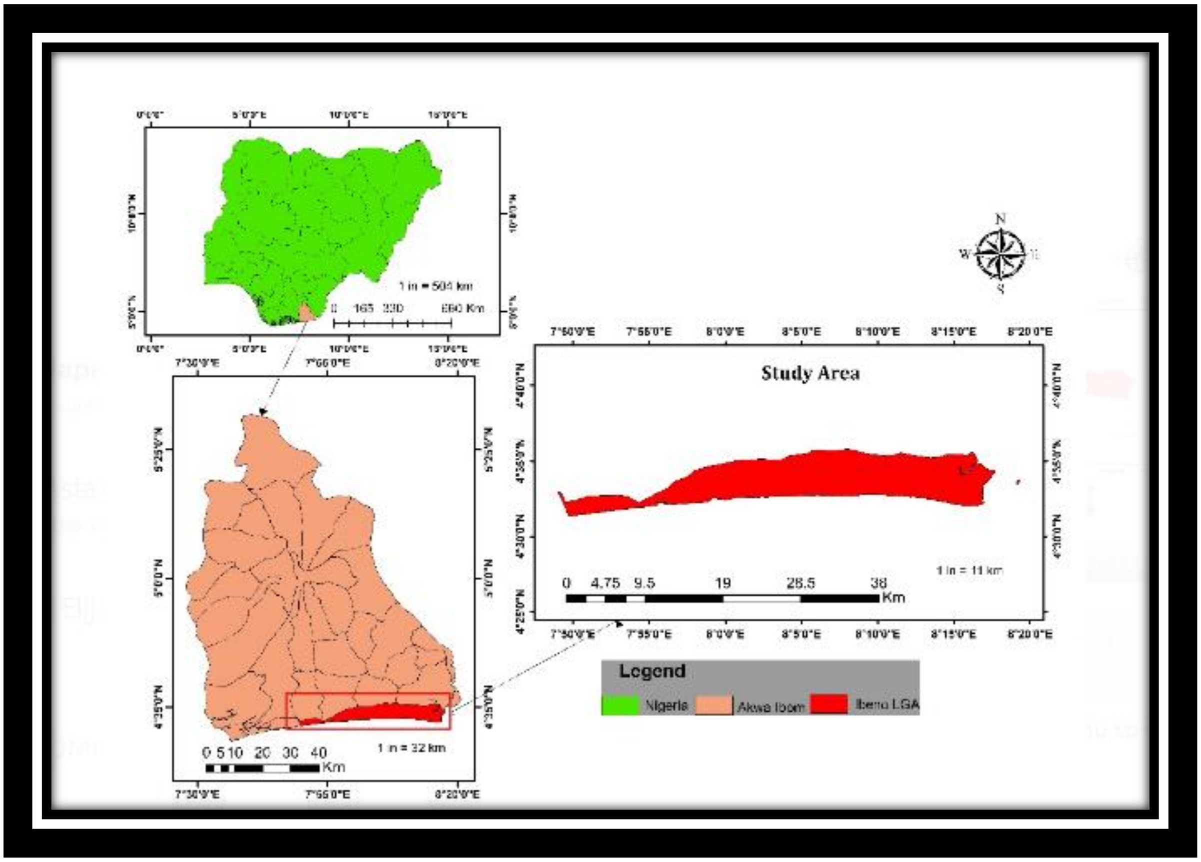


Figure 1: Location of Akwa Ibom State on the Map of Nigeria; Location of the Study Area on the Map of Akwa Ibom State

Figure 2: Sample Locations on Satellite Image of Ibeno Beach Environment: Green spots are sample locations

Study Design

A total of 20 soil samples, 10 water samples, and 10 plant samples were collected from the study area. The soil sample comprised 10 topsoil (0-30cm) and 10 subsoil (30-60cm), collected from 10 locations within the vicinity of Ibeno Beach, with the sample coordinates well-taken using a Global Positioning System (GPS).

Figure 3: Plant Specie sampled at Ibeno Beach and its environs for physicochemical characterization and pollution analysis (left and middle); Atlantic Ocean at Ibeno Beach sampled for water characterization (right)

Sampling and Sample Pre-treatment

Sample Collection

Water, soil and plant/vegetation samples were carried out using standard procedures. Sample containers (plastics for water; polyethylene bags for soil samples, and paper for plant samples) were used for sampling. For conventional analysis, 10 water samples, 10 plant samples, and 20 soil samples were collected and treated accordingly in line with acceptable standards; multiparameter analysis was carried out *in situ* in the study area using a Multifunctional Meter.

A total of 20 soil samples were collected using soil auger that had been well-cleaned with suitable solvent and rinsed accordingly. Samples were collected at depth of between (0-30cm) for topsoil and (30-60cm) for subsoil. The coordinates of the sample locations were taken/documented, and all the samples were properly labeled and preserved and pre-treated prior to analysis using standard procedures. The samples were thereafter taken to the Postgraduate Chemistry Research Laboratory of the University of Uyo, for pre-treatment and analysis.

Sample Analysis

Physicochemical analysis of water, soil, and plants was carried out using standard procedures to ascertain the level of pollution and degradation of the study area. The pH, organic carbon, organic matter, total dissolved solids, chloride and biological oxygen demand were determined in water; electrical conductivity method was used to estimate total dissolved solids (TDS). Chloride (Cl^-) was determined in soil samples while residual moisture content, pH, ash content, electrical conductivity, and colour were determined in plant samples. Some processes were conducted *in situ* at the field while some were done in the laboratory after necessary pre-treatment processes. Major and trace elements including heavy metals were determined using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES). Water, soil and plant samples were digested using wet digestion. A mixture of nitric (HNO_3), perchloric ($HClO_4$) and Hydrochloric (HCl) acids was used for the digestion.

Space-based tools (remote sensing, geographic information system, global positioning system) with ArcGIS software were used to map the study area. Land degradation was geospatially determined via Land Use Land Cover (LULC) of the study area[25,26]. TOPOMAP of Nigeria with special interest in Ibeno Local Government of Akwa Ibom State was used in carrying out land use/land cover analysis[27]. In this process, basic environmental attributes such terrain, hydrology, drainage system, and satellite images from Landsat sensors were used to assess the level of pollution and land degradation in the study area. Landsat TM image of 2003, Landsat image of 2018, and Landsat image of 2024 helped in detecting the changes that occurred at the shore over time. Geographic Information System (GIS) was deployed for unsupervised classification of the environmental features at the study area using digital image processing procedures that included image capturing, image pre-processing (geometric, atmospheric and radiometric corrections), image segmentation, image identification, image classification, image mapping, as recorded by Ahmad and Pandey[28].

RESULTS AND DISCUSSION

Results
Physicochemical Parameter Analysis

The results of the physiochemical parameter studies and metal concentrations in water, soil, and plant samples obtained at Ibeno Beach vicinity in Akwa Ibom State are as presented in Tables 1,2,3,4, 5, 6, 7 and 8 as well as Figures 1, 2. 3. 4. 5, 6 abd 7. Generally, the physiochemical parameter of the study site varied significantly depending on the parameter and environmental media studied.

Physicochemical Parameters of Water

Table 1: Mean of the Physicochemical Properties of Water Samples Ibeno Beach

SAMPLE CODE	pH	Temp. (ºC)	Salt Cont. (ppm)	SG	EC (dS/m)	TDS (mg/L)	DO	BOD (mg/L)	Chloride (mg/L)	Turbidity (NTU)

WS 1	7.49	29.6	25.8	1.016	191	1.34	1.55	0.3	65.85	52.6
WS 2	7.52	30.3	23.8	1	198	1.35	1.54	0.11	40.82	58.4
WS 3	7.53	30.5	27.4	1.002	183	1.39	1.23	0.42	55.26	57.8
WS 4	7.48	29.6	26.1	1.013	189	1.33	1.21	0.41	45.84	58.7
WS 5	7.43	30.1	26.6	1.018	190	1.34	1.13	0.43	65.82	60.2
WS 6	7.45	30	27.6	1.011	194	1.36	1.14	0.52	45.7	60.8
WS 7	7.18	32.6	27.1	1.004	192	1.34	1.25	0.52	35.53	66.3
WS 8	6.51	33.6	27.2	1.001	189	1.5	1.22	0.42	45.85	65.8
WS 9	6.45	34.5	25.1	1.016	187	1.51	1.32	0.31	25.71	57.8
WS 10	7.41	30.5	22.8	1.016	193	1.46	1.3	0.31	30.16	55.6
MEAN	7.245	31.13	25.95	1.01	190.6	1.39	1.29	0.38	45.65	59.4
SD	0.42	1.77	1.61	0.01	4.09	0.07	0.15	0.12	13.62	4.17
MIN	6.45	29.6	22.8	1	183	1.33	1.13	0.11	25.71	52.6
MAX	7.53	34.5	27.6	1.018	198	1.51	1.55	0.52	65.85	66.3

Physicochemical Parameters of Soil

Table 2: Mean of the Physicochemical Properties of Soil Samples Ibeno Beach

Sample Code	depth (cm)	pH	Soil texture Sand	Clay (%)	Silt	Textural classification	OM (%)	OC (%)	EC (dS/m)	EA (mol/kg)	Avail.P (mg/kg)	Al^{3+} (mol/kg)	Total N (%)
SST 1	0-30	6.88	97.8	0.64	1.56	Sandy Soil	1.31	0.76	0.02	0.32	1.25	0.64	0.03
SSS 1	30-60	6.95	97.64	1.2	1.16	Sandy Soil	1.52	0.88	0.03	0.32	0.42	0.48	0.04
SST 2	0-30	6.73	96.68	2.16	1.16	Sandy Soil	1.38	0.8	0.04	0.48	0.83	0.64	0.03
SSS 2	30-60	6.25	98.76	0.76	0.48	Sandy Soil	1.52	0.88	0.09	0.8	0.42	0.48	0.04
SST 3	0-30	7.17	98.04	0.52	1.44	Sandy Soil	1.41	0.82	0.02	0.32	0.42	0.64	0.04
SSS 3	30-60	7.23	98.16	0.92	0.92	Sandy Soil	1.48	0.86	0.02	0.48	0.42	0.48	0.04
SST 4	0-30	6.82	97.64	1.12	1.24	Sandy Soil	2.69	1.56	0.03	0.96	7.5	0.64	0.07

SSS 4	30-60	6.81	97.08	1.08	1.84	Sandy Soil	2.83	1.64	0.03	0.8	6.67	0.64	0.07
SST 5	0-30	6.85	97.12	0.88	2	Sandy Soil	1.04	0.6	0.05	0.48	1.67	0.32	0.03
SSS 5	30-60	6.92	98.12	0.88	1	Sandy Soil	1.59	0.92	0.05	0.64	1.25	0.48	0.04
SST 6	0-30	5.64	94.2	2.08	3.72	Sandy Soil	1.83	1.06	0.05	0.64	4.58	0.48	0.05
SSS 6	30-60	5.86	96.24	2.04	1.72	Sandy Soil	1.9	1.1	0.05	0.8	3.75	0.48	0.05
SST 7	0-30	5.58	90.28	4.08	5.64	Sandy Soil	2.55	1.48	0.06	0.8	5.42	0.64	0.06
SSS 7	30-60	6.02	96.28	2.04	1.68	Sandy Soil	2	1.16	0.03	0.64	8.75	0.32	0.05
SST 8	0-30	5.09	90.4	4.04	5.56	Loamy Sand	1.76	1.02	0.03	0.48	8.75	0.48	0.04
SSS 8	30-60	4.94	86.48	6	7.52	Sandy Soil	4	2.31	0.04	0.32	13.75	0.16	0.1
SST 9	0-30	5.17	94.56	2	3.44	Sandy Soil	1.93	1.12	0.02	0.8	10	0.48	0.05
SSS 9	30-60	5.4	98.76	0.6	0.64	Sandy Soil	2.21	1.28	0.02	0.64	7.5	0.32	0.06
SST 10	0-30	5.3	98.8	0.76	0.44	Sandy Soil	1.35	0.78	0.02	0.8	2.08	0.48	0.03
SSS 10	30-60	5.64	98.76	0.52	0.72	Sandy Soil	1.52	0.88	0.04	0.48	1.25	0.64	0.038
MEAN		6.16	96.09	1.72	2.19		1.89	1.09	0.04	0.6	4.33	0.5	0.05
SD		0.78	3.37	1.45	1.97		0.69	0.4	0.02	0.2	3.98	0.14	0.02
MIN		4.94	86.48	0.52	0.44		1.04	0.6	0.02	0.32	0.42	0.16	0.03
MAX		7.23	98.8	6	7.52		4	2.31	0.09	0.96	13.75	0.64	0.1

SST – Soil Sample (Top); SSS – Soil Sample (Sub)

Physicochemical Properties of Plant Samples

Table 3: Physicochemical Properties of Plant Samples from Ibeno Beach

	PHYSICOCHEMICAL PARAMETERS				
SAMPLE	pH	Residual Moisture	Ash Content	EC	Colour of dried plant sample

CODE		Content (%)	(%)	(dS/cm)	
PS 1	5.81	0.46	15	5.64	5 YR (5/3) Olive
PS 2	5.65	0.52	10	5.16	5 YR (4/3) Olive
PS 3	5.37	0.46	10	5.48	5 YR (6/3) Pale Olive
PS 4	6.01	0.43	14	4.56	10 YR (6/2) Light Greyish Olive
PS 5	5.75	0.4	16	4.71	5YR (4/3) Olive
PS 6	5.44	0.33	10	3.08	5 YR (6/4) Pale Olive
PS 7	4.76	0.49	7	3.37	5 YR (4/2) Olive Gray
PS 8	5.35	0.51	2	5.88	2.5 YR (4/3) Olive Brown
PS 9	5.38	0.49	9	4.25	2.5 YR (4/3) Olive Brown
PS 10	5.98	0.43	7	6.63	10 YR-5GY (4/4) Olive
MEAN	5.55	0.452	10	4.876	
SD	0.37	0.06	4.22	1.11	
MIN	4.76	0.33	2	3.08	
MAX	6.01	0.52	16	6.63	

Heavy Metals Analysis

Table 4: Mean Concentrations of Metals in the Water Samples taken from Ibeno Beach and its Vicinity

S/N	**Sample Code**	**Coordinates**	**Heavy Metal Level (mg/L)**		
			Lead (Pb)	**Nickel (Ni)**	**Chromium (Cr)**
1	WS 1	04°32'19.5"N; 008°00'12.0"E	BDL	0.02	0.01
2	WS 2	04°32'19.0"N; 008°00'09.0"E	BDL	0.01	BDL
3	WS 3	04°32'18.2"N; 008°00'05.8"E	BDL	0.02	0.01
4	WS 4	04°32'17.7"N; 008°00'03.9"E	BDL	0.02	BDL
5	WS 5	04°32'17.2"N; 007°58'36.5"E	BDL	0.02	BDL
6	WS 6	04°32'16.9"N; 007°59'38.15"E	0.02	0.03	0.01
7	WS 7	04°32'4.8"N; 008°42'35.02"E	0.04	0.02	0.01

8	WS 8	04°32'46.15"N; 008°02'49.28"E	0.01	0.02	BDL
9	WS 9	04°34'08.24"N; 007°58'31.5"E	0.01	0.01	BDL
10	WS 10	04°34'02.13"N; 007°58'30.08"E	0.01	0.07	BDL

Table 5: Mean Concentrations of Metals in Soil Sample taken from Ibeno Beach and its Vicinity

S/N	**Sample Code**	**Depth**	**Coordinates**	**Heavy Metal Levels (mg/kg)**		
				Pb	**Ni**	**Cr**
1	SST 1	0-30	04°32'20.0"N; 008°00'12.0" E	7.34	3.92	2.31
2	SSS 1	30-60	04°32'20.0"N; 008°00'12.0" E	5.49	BDL	2.71
3	SST 2	0-30	04°32'19.0"N; 008°00'09.0" E	0.04	0.01	0.01
4	SSS 2	30-60	04°32'19.0"N; 008°00'09.0" E	BDL	2.56	3.68
5	SST 3	0-30	04°32'18.2"N; 008°00'05.8"E	3.72	BDL	4
6	SSS 3	30-60	04°32'18.2"N; 008°00'05.8"E	4.21	4.96	9.69
7	SST 4	0-30	04°32'17.7"N; 008°00'03.9"E	10.02	BDL	7.7
8	SSS 4	30-60	04°32'17.7"N; 008°00'03.9"E	7.18	3.78	2.77
9	SST 5	0-30	04°32'17.2"N; 007°58'36.5"E	BDL	5.06	2.18
10	SSS 5	30-60	04°32'17.2"N; 007°58'36.5"E	7.48	5.18	3.76
11	SST 6	0-30	04°32'16.9"N; 007°59'38.15"E	10.05	4.73	5.66
12	SSS 6	30-60	04°32'16.9"N; 007°59'38.15"E	BDL	BDL	3.28
13	SST 7	0-30	04°32'49.3"N; 008°02'42.15"E	BDL	4.26	2.58
14	SSS 7	30-60	04°32'49.3"N; 008°02'42.15"E	BDL	BDL	3.28
15	SST 8	0-30	04°32'31.04"N; 008°02'46.09"E	8.3	BDL	3.1
16	SSS 8	30-60	04°32'31.04"N; 008°02'46.09"E	8.86	BDL	2.74
17	SST 9	0-30	04°34'08.24"N; 007°58'26.09"E	BDL	BDL	2.08

18	SSS 9	30-60	04°34'08.24"N; 007°58'26.09"E	7.25	BDL	2.2
19	SST 10	0-30	04°34'02.13"N; 007°58'30.08"E	14.69	2.45	2.57
20	SSS 10	30-60	04°34'02.13"N; 007°58'30.08"E	51.59	3.36	1.91

Table 6: Mean Concentrations of Metals in Plant Samples taken from Ibeno Beach and its Vicinity

S/N	**Sample Code**	**Coordinates**	**Heavy Metal Levels (mg/kg)**		
			Pb	**Ni**	**Cr**
1.	PS 1	04°32'21.3"N; 007°59'48.4" E	BDL	3.12	0.73
2.	PS 2	04°32'49.5"N; 007°59'51.0" E	BDL	BDL	BDL
3.	PS 3	04°32'19.9"N; 007°59'57.0"E	BDL	3.55	0.97
4.	PS 4	04°32'31.4"N; 008°00'9.8"E	3.87	6.84	2.42
5.	PS 5	04°32'29.1"N; 008°00'14.5"E	3.97	2.49	1.15
6.	PS 6	04°32'28.3"N; 008°00'23.2"E	6.19	20.52	13
7.	PS 7	04°32'36.3"N; 008°02'37.4"E	3.3	6.57	3.06
8.	PS 8	04°32'36.5"N; 008°02'49.6"E	1.48	13.24	4.24
9.	PS 9	04°34'10.0"N; 007°58'30.08"E	3.98	8.96	7.19
10.	PS 10	04°34'07.3"N; 007°58'29.15"E	2.24	2.66	BDL

Table 7: Land Use Land Cover (LULC)/Change at Ibeno Beach and its Vicinity (Ibeno LGA) between 2003 and 2024

AREA (Km^2)

CLASS	2003	2018	2024	∆(2003-2018)	∆(2018-2024)	∆(2003-2024)
BUILTUP	14.02	17.23	19.32	3.22	2.09	5.3
FOREST	167.31	156.3	140.89	-11.01	-15.41	-26.42
FARMLAND	35.24	7.7	15.54	-27.53	7.84	-19.7
SHRUBLAND	14.08	42.02	53.57	27.94	11.55	39.49
WATERBODY	8.49	13.2	11.37	4.71	-1.82	2.88
BARELAND	0.66	0.6	2.25	-0.06	-5.89	-3.15
TOTAL	**243.26**	**243.26**	**243.26**			

Table 8: Heavy metal levels in water, soil and plant samples and selected standards/limits

Element	Range in Water	Soil	Plant	EPA Limits	WHO Upper Limits	FEPA Stds	NIS Stds	CRS Std in Soil		Non-Cont Soil Plant
	mg/L	mg/kg	mg/kg	mg/L	mg/L	mg/L	mg/L	mg/kg	mg/kg	mg/mg
Pb	0.01-0.04	0.01-14.69	1.48-6.19	0.05	0.05	0.01	0.01	-	10-70	2
Ni	0.01-0.07	0.01-5.18	2.49-20.52	-	-	0.02	0.02	5-100	0.5-50	10
Cr	0.1	0.01-9.69	0.73-13	0.05	0.05	0.05	0.05	10-300	-	1.3

Sources: [44]Townsend *et al*., 2005 [46]WHO, 1984; [45]FEPA, 1991 NIS, 2015 Bonn *et al.*, 1985 Salami, 2011 [43]Babatunde, 2000

Discussion

Water pH

The soil pH of the study site varied within the overall range 6.45-7.53; with the water sample obtained from location 3 (WS 3) having the highest mean value and the one taken from location 9 having lowest value 6.45 with range (6.45-7.53). The pattern based on increasing pH of water is presented thus: WS 9< WS 8 <WS 7< WS 10 <WS 5 < WS 6 < WS 4 < WS 1 < WS 2 < WS 3. The results revealed that the pH of the water were between slightly basic and slightly acidic. The mean pH values ranging from 6.45-7.53, were within the recommended pH for ocean/drinking water. The obtained pH levels were not far from 7.0 which is the pH of pure water and 8 which is the pH of ocean water[29]. The pH of water varies due to the presence of dissolved salts and carbonates, as well as the mineral composition of the surrounding soil. The pH levels were within the pH limits recommended for most fish which is between 6.0 and 9.0[30]. The overall mean pH value of 7.25 and range of 6.45-7.53 fell within the range limit (6.5-8.5) recommended by the Nigerian Industrial Standard, NIS for drinking water[31].

Water Temperature

The temperature of the water body studied varied between 29.6ºC and 34.5ºC with a mean of 31.13ºC. The highest temperature (34.5ºC) was recorded for SW 9 while the minimum was recorded for WS 1. The mean temperature of the water was observed to be higher than the ambient temperature of 28.0ºC) which is Nigerian Standards for Drinking Water Quality, and the WHO standard temperature (27.0 - 28.0ºC) for drinking water. The higher temperature of the water system may be attributed to contributions from the environment such as anthropogenic activities, continuous tidal movement of the ocean water, high intensity of ultraviolet radiation from the sun, chemical/biochemical reactions, among other factors. The general trend was WS1 = WS4 < WS6 < WS5 < WS2 < WS3 = WS10 < WS7 < WS9. The relative high temperature recorded has significant implications on the pollution level and quality of water. It can lead to increased solubility of oxygen; can increase availability of nutrient and stimulates algal as well as bacterial growth and also impacts on the pH and alkalinity level of the water, making it more susceptible to pollution. More importantly, there is possibility of increased reactivity of chemicals in water and mobility pollutants including heavy metals and persistent organic pollutants in the water.

Salt and Chloride Contents

The salt content (ppm) of the water varied significantly between 22.8ppm and 27.6 ppm, with the highest level recorded for the sample taken at location 6 (WS 6) at the Beach while the least level was recorded for the sample taken at location 10 (WS 10) at Upenekang waterside. The high salt level is the characteristic of a typical ocean water with elevated sodium, potassium, calcium and chloride content, and is generally saline. High salinity level in water can affect aquatic lives in terms of behaviour, respiration, reproduction, feeding and adaptability or survival. The overall mean salt content of 25.95$\pm$ 1.61 ppm was high for drinking water. The general trend was WS 10 < WS 2 < WS 9 < WS 1 < WS 4 < WS 5 < WS 7 < WS 8 < WS 3 < WS 6. The samples generally had high chloride contents ranging from 25.71mg/L to 65.85mg/L with the highest level recorded for WS1 and least for WS 9. The mean level of 45.65+13.62 mg/L was lower than the permitted limit for drinking water by the Nigerian Industrial Standard (200 mg/L). High salt content can increase the corrosiveness, pH and alkalinity of water. it can lead to increased scaling and fouling, changes in the composition of aquatic organisms, increased mobility of water pollutants, increased risk of salinisation, and can affect the overall quality of the water ecosystem.

Specific Gravity

The specific gravity (SG) of the water (relative density) varied significantly from 1 to 1.018 with the least value observed for sample 2 (WS 2) while maximum value was recorded for sample 5 (WS 5). The overall mean value of 1.01± 0.01 was almost the specific gravity of water (1), meaning the different specific gravities were within range. The general trend in increasing order of magnitude was WS 2 < WS 8 < WS 3 < WS 7 WS 6 < WS 4 < WS 1 = WS 9 = WS 10 < WS 5. The specific gravity range (1-1.018) indicates that the water samples were of the same value with, and some slightly denser than pure water. It suggested the presence of dissolved solids such as salts, minerals, other inorganic compounds or contaminants in the soil. It suggested low to moderate levels of pollution. It also suggested the presence of dissolved solids and potential changes in water quality that may impact negatively on aquatic life sand human health, among others. Generally, the specific gravity of water is dependent on the temperature of the water body and the amount of impurity in water.

Electrical Conductivity

Electrical conductivity varied slightly between 183 and 198, with a mean of 190.6 and 4.09. The highest electrical conductivity was observed for WS2, while the least was observed in WS3. The general trend in increasing magnitude was WS 3 < WS 9 < WS 4 = WS 8 < WS 5 < WS 1< WS 7 < WS 10 < WS 2. The elevated electrical conductivity the water samples might have been as a result of high concentration of dissolved salts (salinity) of the water studied and the temperature of the water salts such as sodium chloride which dissociates in water to form ions Na^+ and Cl^- that migrate in presence of an electric field, and thereby resultantly producing an electric current. Conductivity of water is a measure of the capability of water to pass electrical current[32].

Total Dissolved Solids

The Total Dissolved Solids (TDS) content of water samples studied were found to vary slightly with a mean of 1.39±0.07 mg/L with a range between 1.33 mg/L (WS 4) and 1.51 mg/L (WS 9). The levels were generally low compared to the permissible limit of 500 mg/L allowed by the Nigerian standards for drinking water. The general trend in increasing order of magnitude was WS 4 < WS 1 = WS 5 =WS 7 < WS 2 < WS 6 < WS 3 < WS 10 < WS 8 < WS 9. TDS is detrimental to fish health by decreasing growth, disease resistance, and egg development. It also contributes to turbidity which limits the penetration of light for photosynthesis and visibility in recreational water such as Atlantic Ocean at Ibeno Beach under study.

Dissolved Oxygen

Dissolved oxygen is a measure of how much oxygen is dissolved in water, varied slightly with a range of 1.13 to 1.55, with the highest level recorded for WS1 while the least was recorded for WS5 for the water samples. The general trend in order of increasing magnitude was WS5 < WS6 < WS4 < WS8 < WS3 < WS7 < WS10 < WS9 < WS2 < WS1. The averagely low dissolved oxygen in the water samples indicated that the amount of oxygen available for living organisms in the water was generally low, an indication of the unhealthy nature of the ocean water. Healthy water generally has dissolved oxygen above 6.5 to 8.0 mg/L

Biological Oxygen Demand (BOD)

The Biological Oxygen Demand (amount of dissolved oxygen needed by aerobic biological organisms to break down organic materials present in water at certain temperatures over a specific period of time) as presented in Table 1 was generally low and varied between 0.11 and 0.52 mg/L, with a mean concentration of 0.38±0.12 mg/L. The highest concentration of 0.52 mg/L was detected in sample 6 (WS 6) while the lowest of 0.11 mg/L was detected in sample 2 (WS 2). BOD of water is of environmental interferences as it helps to determine the quality of water as well as the oxygen level. The BOD concentrations in all the samples tested were lower than the value for moderately polluted water (2-8 mg/L). The obtained BOD were between low and high. Higher BOD between 0.41 and 0.52 mg/L indicates poor water quality and significant organic and inorganic pollution which can be harmful to aquatic life and human. It also indicated significant oxygen depletion in the water.

Turbidity

Turbidity of water studied ranged from 52.6 to 66.3 NTU with an overall mean of 59.4±4.17 NTU. The highest turbidity was recorded for WS7 while the lowest was recorded for WS 1. The general trend in increasing order of magnitude was WS 1 < WS 10 < WS 3 = WS 9 < WS 2 < WS 4 < WS 5 < WS 6< WS 8< WS 6. The turbidity levels of the water studies revealed high to very high levels of suspended solids in the water. High turbidity is likely to reduce light penetration, affecting photosynthesis and other life processes in water. it can increase the risk of waterborne diseases and can cause unpleasant odour, taste and appearance of the water body. Very high turbidity (about 66.3 NTU) can indicate the presence of toxic substances such as heavy metals or pesticides which can harm human and aquatic life[33]. The high turbidity of the ocean water may have been caused by soil erosion, urban runoff, leachates from fertilizer and agricultural products, waste discharge, bottom feeders, sediment concentration and algal growth, among others. According to the Nigerian Industrial Standards[34], turbidity has no direct health impact but can help to harbour microorganisms, protecting them from disinfection and can entrap heavy metals and biocides. The more total suspended solids in the water, the cloudier the water, and the higher the turbidity[35].

Soil pH

The soil pH of the study area varied significantly within the range 4.94-7.23, with the soil obtained at point 3 (SSS 3; sub-soil) having the highest value of 7.23, followed by the one obtained at the same location but top soil (SST, pH of 7.17). The mean of all the recorded pH was 6.16+0.78. The order of increasing soil pH was SSS 8<SST 8 < SST 9 < SST 10 < SSS 9 < SST 7 < SST 6 = SSS10

< SSS 6 < SSS 7 < SSS 2 < SST 2 < SSS 4 < SST 4 < SST 5 < SST 1 < SSS 5 < SSS 1 < SST 3 < SSS 3. The results revealed that the pH of the soil were between acidic and slightly alkaline. The mean pH values which ranged from 4.94-7.23 were within the recommended pH for tropical mineral soils (5.50-7.50), except the lowest pH level recorded for SSS 8. The pH of 4.94-7.23 (acidic to slightly alkaline soil condition) may have far-reaching implications on toxicity, nutrient availability, and fertility of the soil. Acidic soils such of this nature have limited availability of essential nutrients and high levels of aluminium, manganese, sodium and heavy metals which can be toxic to plants and microorganisms. It can also alter the microbial content of the soil, leading to reduced soil fertility and increased greenhouse gas emissions. The pH of soil is an important parameter that directly influences sorption/desorption, precipitation, dissolution, reduction-oxidation reaction, and complex formation of the soil. pH also plays an important role in the mobilization and immobilization of heavy metals from the soil environment[36].

Soil Texture

Results of textural analysis and classification of the soil samples revealed sand being the most dominant fraction at all the locations studied. All the samples analysed contained more than 90% of sand particles except the sub-soil sample obtained at sample point 8 (SSS 8), which contained only 86.48% of sand. The overall mean of the sand content was 96.09$\pm$3.37 % and ranged from 86.48 to 98.9. The general trend of sandy constituents in increasing order of magnitude was SSS 8 < SST 7 < SST 8 < SST 6 < SST 9 < SSS 6 < SSS 7 < SST 2 < SSS 4 < SST 5 < SSS 1 = SST 4 < SST 1 < SST 3 < SSS 5 < SSS 3 < SSS 2 = SSS 9 = SSS 10 < SST 10. The clay content also varied significantly between 0.52 to 6% with overall mean of 1,72$\pm$1.45 %. The minimum clay content was recorded for sample SST 3 while the maximum content (6%) was recorded for sample SSS 8. The clay content for the samples were generally low compared to the sand content. The general trend in increasing order of magnitude was SST 3 < SSS 10 < SSS 9 < SST 1 < SSS 2 < SST 10 < SST 5 < SSS 5 < SSS 3 < SSS 4 < SST 4 < SSS 1 < SST 9 < SSS 6 < SSS 7 < SST 6 < SST 2 < SST 8 < SST 7 < SSS 8. The Silt content also varied significantly from 0.44% (SST 10) to 7.52% (SSS 8), with an overall mean of 2.19$\pm$1.97. The silt content of the soil samples was generally low compared to the sand content. The general trend in increasing order of magnitude was SST 10 < SSS 2 < SSS 9 < SSS 10 < SSS 3 < SSS 5 < SSS 1 = SST 2 < SST 4 < SST 3 < SST 1 < SSS 7 < SSS 6 < SSS 4 < SST 3 < SST 1 < SSS 7 < SSS 6 < SSS 4 < SST 5 < SST 9 < SST 6 < SST 8 < SST 7 < SSS 8. Soil texture plays a major role in the general functioning and stability of the soil and can affect the level of pollution in soil by influencing how pollutants are bound to soil particles and move through the soil[37]. Sandy soil of this nature has low water holding capacity, high infiltration rate, poor soil structure, low cation exchange capacity (CEC), high nutrient deficiency, high leaching tendencies, low resistance to environmental forces such as rainfall and wind, and general low productivity.

Soil Organic Carbon and Organic Matter

The organic carbon and organic matter contents of soil from the study area were generally low. The organic carbon content was low too, ranging from 0.6 % to 2.31. The overall mean was 1.09±0.4%. The organic matter content fell between 1.04% (SST 5) and 4% (SSS 8), with the overall mean of 1.89±0.59%. The low organic matter and organic carbon may be attributed to continuous abrasive forces, wind, rainfall, anthropogenic factors, and general geochemical contributions around the Beach. The general trend was SST 5< SST 1 < SST 10 < SST 2 < SST 3 < SSS 3 < SSS 1 = SSS 2 = SSS 10 < SSS 5 < SST 8 < SST 6 < SSS 6 < SST 9 < SSS 7 < SSS 9 < SST 7 < SST 4 < SSS 4 < SSS 8. The Organic Carbon also followed a similar trend: SST 5< SST 1 < SST 10 < SST 2 < SST 3 < SSS 3 < SSS 1 = SSS 2 = SSS 10 < SSS 5 < SST 8 < SST 6 < SSS 6 < SST 9 < SSS 7 < SSS 9 < SST 7 < SST 4 < SSS 4 < SSS 8. Soil organic matter is a major contributor of soil carbon, and it plays a key role in the degradation of pollutants in soil (Liu *et al.*, 2006). Organic matter also plays an important role in cation exchange and formation of complexes in soil as well as adsorption reactions that prevent heavy metal from reaching ground and surface water sources[38].

Electrical Conductivity of the Soil

Electrical conductivity of soil, according to the result in Table 2, varied slightly between 0.2 and 0.9, with overall mean being 0.04±0.02 dS/m. The minimum conductivity was noticed for six samples (SST 1, SST 3, SSS 3, SSS 9, SST 10) while the maximum value of 0.9 dS/m was recorded for sample SSS 2. The relative low conductivity measured in all the samples may be due the sandy nature of the soil which results in a reduced amount of available charged particles compared to clay or loamy soil. Soil electrical conductivity (EC) is expressed in deci Siemens per meter (dS/m) and is a measure of the ability of soil water to carry electrical current. Factors influencing the electrical conductivity of soils are numerous, including the amount of soluble salts in the soil, porosity of the soil, type of soluble salts in solution, soil texture, temperature and soil moisture, among others[39]. As a result of its sensitivity to soluble salts, electrical conductivity is an effective measure for assessing the contamination of surface and ground water[39]. The general trend in order of increasing magnitude was SST 1 = SST 3 = SSS 3 = SST 9 = SSS 9 = SST 10 < SSS 1 = SST 4 = SSS 4 = SSS 7 = SST 8 < SST 2 = SSS 8 = SSS 10 < SST 5 = SSS 5 = SST 6 = SSS 6 < SST 7 < SSS 2. Electrical conductivity of soil between 0.2 – 0.9dS/m indicates relatively low to moderate levels of salinity and ionic activity in the soil. It also suggests low to moderate levels of pollution, as high EC values are often associated with high levels of salts, ions, and pollutants. At higher EC values, there is high potential for nutrient pollution, soil salinization, and soil degradation[40].

pH of Plant

The pH of the plant samples varied slightly and were mostly slightly acidic between 4.76 and 6.01. The highest pH was observed for plant sample 4 (PS 4) obtained at Ibeno Beach and the minimum observed for sample PS 7 taken from Ndito Ekaiba village near Ibeno Beach. The highest pH value observed for PS4 may be attributed to anthropogenic contributions through domestic discharges and agricultural activities. The general trend in increasing order of magnitude was PS 7 < PS 8 < PS 3 < PS 9 < PS 6 < PS 2 < PS 5 < PS 1 < PS 10 < PS 4.

Residual Moisture Content

The residual moisture content (the amount of water remaining in plant materials after processing or drying), in the plant samples as observed in Table 3 varied slightly between 0.33% to 0.52%. The least residual moisture content was recorded for PS 5 while the highest percentage was observed for PS 6, with the overall mean of 0.45$\pm$0.06. The general trend was PS 6 < PS 5 < PS 4 < PS 1 = PS 3 PS 3 < PS 7 = PS 9 < PAS 8 < PS 2. The residual moisture content has significant implications on plant health and environmental pollution. Excess moisture in plant can lead to fungal and bacterial growth, causing spoilage and reducing plant qualities, and excess moisture can leach plant nutrients from plant to tissues.

Ash Content

The ash content of the plant samples is the percentage of inorganic materials remaining after a plant material is burnt or decomposed. Ash content of the plant samples varied significantly between 2% and 16%, with an overall mean of 10$\pm$2.21. The highest ash content was noted in PS 5 while the lowest was noted in PS 8. The differences in the ash content may be as a result of the type of plant, location of the plant, plant age/maturity, atmospheric exposure, agricultural practices, and the nutrient constituent of the soil where the plant was harvested. The general trend was PS 8 < PS 7 = PS 10 < PS 9 < PS 2 = PS 3 = PS 6 < PS 4 < PS 1 < PS 5. High ash content can indicate excessive minerals uptake which could potentially harm plant growth, and the ash from plant can accumulate in soil and resultantly alter the pH thereby affecting nutrient availability.

Electrical Conductivity

The electrical conductivity of plants is a measure of the ability of plant tissues to conduct electricity, and it indicates the ions and water content. EC of plant affects the plant’s ability to uptake nutrients which influences plant growth; it influences ions distribution, while impacting significantly on plant’s ability to photosynthesize and metabolize. Electrical Conductivity (EC) of the plant samples varied significantly between 3.08 and 6.63 dS/cm, with the highest observed in PS 10 while the lowest was noted in PS 6. The overall mean was

4.88±1.11. The trend in increasing order was PS 5 < PS 1 < PS 4 < PS 10 < PS 7 < PS 6 < PS 3 < PS 8 < PS 2 < PS 9. The EC range obtained in the study area was between moderate and high, and indicates high salt levels, nutrient imbalances, and irrigation management issues[41].

The levels of lead (Pb) detected in water samples were generally low, ranging from 0.01 to 0.04 mg/L. The minimum level was recorded for WS 8, WS 9, WS 10 while the maximum was recorded for WS 7. No Pb was detected for samples WS 1, WS 2, WS 3, WS 4 and WS 5. The general trend in order of increasing magnitude was WS 8 = WS 9 = WS 10 < WS 6 < WS 7. The maximum level (0.4 mg/L) detected was lower than the upper limit (0.05 mg/L) limited set by World Health Organization, (WHO, 1984; Babatunde, 2000) for drinking water and 5.0 mg/L EPA regulatory limit (Townsend *et al.*, 2003). Ni was however detected in all the water samples detected, with lowest concentration recorded for WS 2 while the highest level was recorded for WS 10. The general trend of Ni levels in increasing order of magnitude was WS 2 = WS 9 < WS 1 = WS 3 = WS 4 = WS 5 = WS 7 = WS 8 < WS 6 < WS 1. The levels of Ni varied between 0.1 and 0.07 mg/L, with the lowest recorded for WS 2 and the highest recorded for WS 10. Cr was detected in water samples WS 1, WS 3, WS 6 and WS 7. The levels, 0.03 mg/L and 0.07 mg/L recorded for WS 6 and WS 7 respectively was higher than the limit of 0.02 mg/L set for Ni in water (FEPA, 1991). Cr in samples WS 2, WS 4, WS 5, WS 8, WS 9 and WS 10 were below detection level. The maximum level of Cr detected (0.01 mg/L) was far less than the upper limit (0.05 Mg/L) set by[42]. High level of Pb in water can cause cancer, interference with vitamin D metabolism, impact negatively on mental development in infants, and toxic to the central and peripheral nervous systems. Too much of Ni or Cr can be carcinogenic.

The levels of Pb, Ni, and Cr in the soil samples were generally high, with Pb ranging from 0.04-51.59 mg/kg; Ni from 0.01-5.18 mg/kg; and Cr from 0.01-9.69mg/kg. The trend of Pb in increasing order of magnitude was SST 2 < SST 3 < SSS 3 < SSS1 < SSS 4 < SSS 9 < SST 1 < SSS 5 < SST 8 < SSS 8 < SST 4 < SST 6 < SST 10 < SSS 10. Pb was not detected for SSS 2, SST 5, SSS 6, SST 7, SSS 7 and SST 9. Minimum level of Pb was recorded for SST 2 and maximum for SSS 10. The trend in Ni levels was SST 2 < SST 10 < SSS 2 < SSS 10 < SSS 4 < SST 1 < SST 7 < SST 6 < SSS 3 < SST 5 < SSS 5. No Pb was detected for samples SSS 1, SST 3, SST 5, SSS 6, SSS 7, SST 8, SSS 8, SST 9 and SSS 9. Minimum level was recorded for SST 2 while maximum was recorded for SSS 5. Cr levels in order of increasing magnitude was SST 2 < SSS 10 < SST 9 < SST 5 < SSS 9 < SST 1 < SST 10 < SST 7 < SSS 1 < SSS 8 < SSS 4 < SST 8 < SSS 6 = SSS 7 < SSS 2 < SSS 5 < SST 3 < SST 6 < SST 4 < SSS 3. The minimum level was recorded for SST 2 while the maximum was recorded for SSS 3.

The concentration of Pb, Ni and Cr were generally high in the plant samples studied. The range were

Pb (1.48-6.19), Ni (2.49-20.52), Cr (0.73-13) all in mg/kg. The general trend in the levels of Pb in the plant samples was PS 8 < PS 10 < PS 7 < PS 4 < PS 5 < PS 9 < PS 6. Pb was not detected foe samples PS 1, PS 2, and PS 3. Minimum level was recorded for PS 8 while maximum was recorded for PS 6. Ni trend was PS 5 < PS 10 < PS 1 < PS 3 < PS 5 < PS 4 < PS 9 < PS 8 < PS 6. No Ni was detected for PS 2. Minimum level was recorded for PS 5 while maximum was recorded for PS 6. The general trend for Cr was PS 1 < PS 3 < PS 5 < PS 4 < PS 7 < PS 8 < PS 9 < PS 6. No Cr was detected for PS 2 and PS 10. The minimum level was recorded for PS 1 and maximum recorded for PS 6.

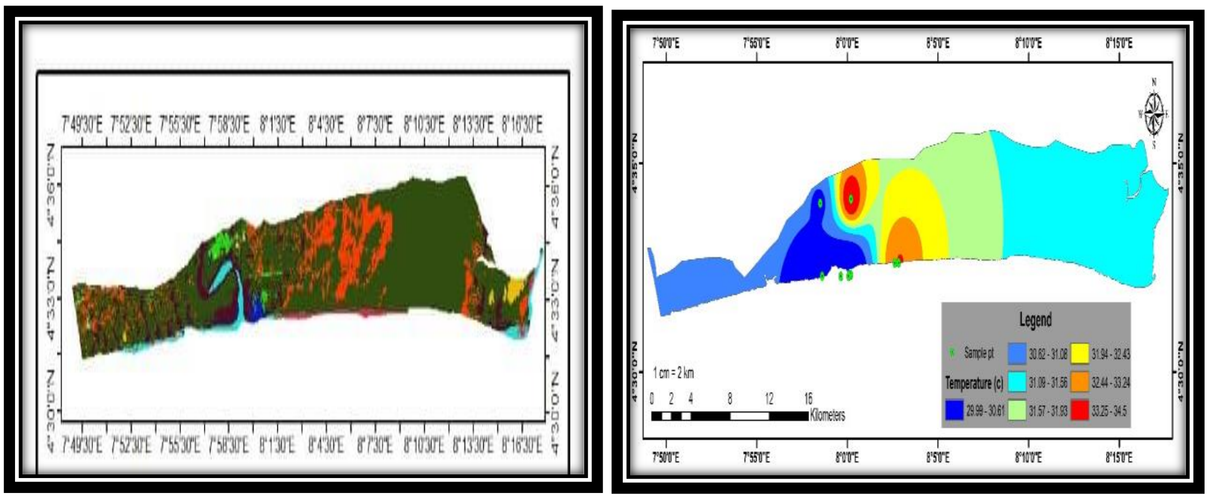
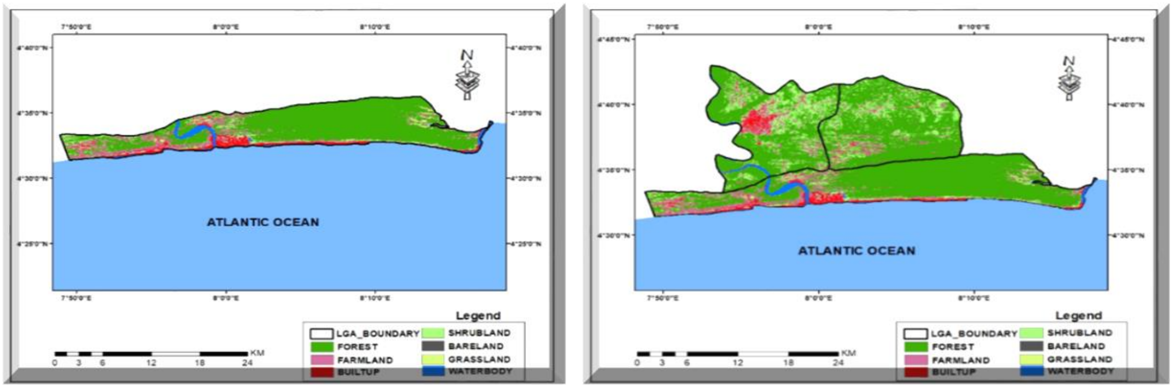


Figure 4: 2024 Digital Terrain Model of the Study Area (left); temperature of Study Area measured geospatially (right)

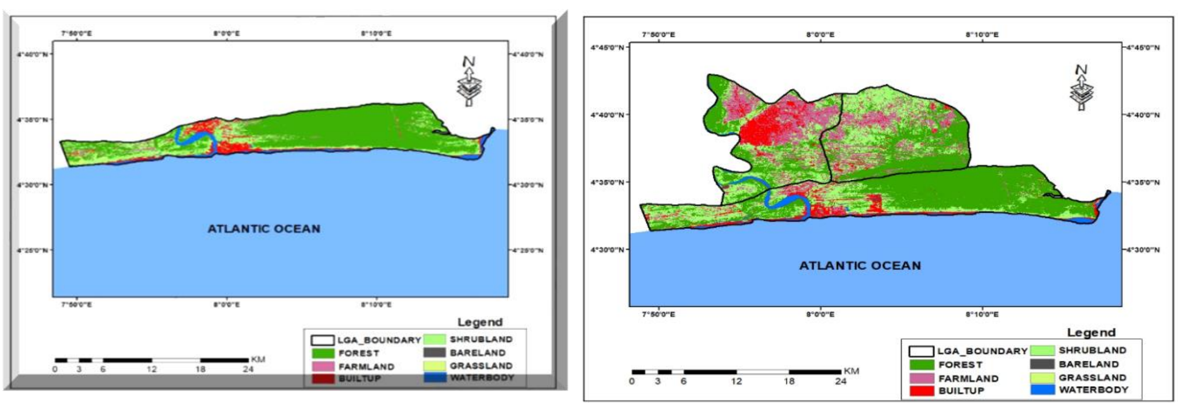
Geospatial Analysis

Change Detection for Degradation Analysis



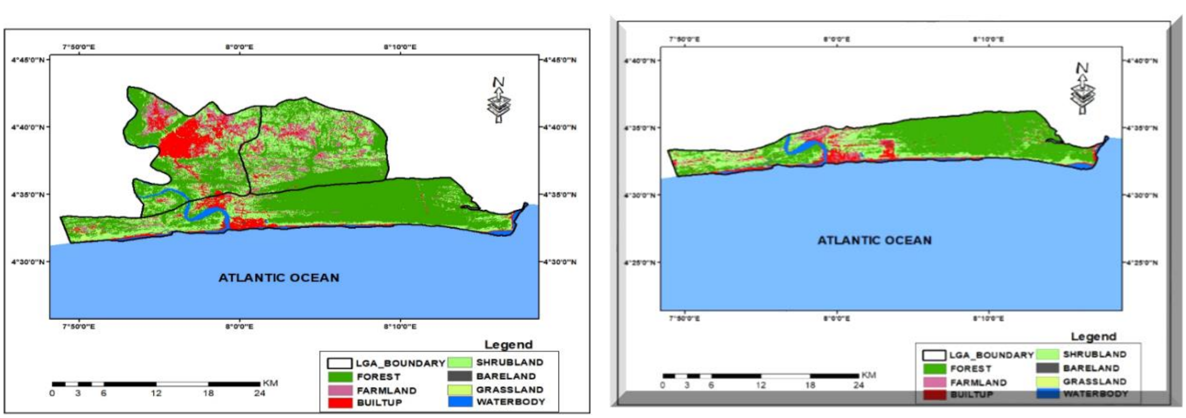
2003

Figure 5: 2003 Land use land cover/Change detection of Ibeno Beach environment - Ibeno Local Governement (left); change detection of Ibeno, Eket and Esit Eket Local Government Areas (right)



2018

Figure 6: 2018 Land use land cover/Change detection of Ibeno Beach environment - Ibeno Local Governement (left); change detection of Ibeno, Eket and Esit Eket Local Government Areas (right)



2024

Figure 7: 2024 Land use land cover/Change detection of Ibeno Beach environment - Ibeno Local Governement (left); change detection of Ibeno, Eket and Esit Eket Local Government Areas (right)

Change Detection Analysis

The land use land cover analysis of Ibeno LGA over a period of 21 years using a 3-time period (2003, 2018 and 2024) revealed a signifigant feature change in the area under study, and indication of probable degradation in the area. The study area classified into seven (7) classes (buildup area, forest, farmland, shrubland, water body, bareland, and grassland) revealed significant changes in the geophysical morphology of the area as shown in Table 10. Remotely sensed data analysed geospatially revelaed that in 2003, most of the area was covered with forest and the least significant coverage was bareland (167.31km^2) with the area of 0.66 km^2. The general trend in order of increasing magnitude was bareland < grassland < water body < buildup area < shrubland < farmland < forest. The feature classes in 2018 compared to 2003 revealed an increase in the buildup area, increase in forest coverage, significant decrease in farmland, increase in shrubland, increase in water body and slight decrease in bareland. The increase in water body may have been caused by seasonal changes and the decrease in forested area may have been caused by human activities such as lumbering, bush burning, while the increase in buildup area might have been as a result of developmental activities in the area. The general trend in 2018 was bareland < grassland < farmland < water body < buildup < shrubland < forest. The area claaification of 2024 compared to 2018 revealed a slight increase in buildup area, decrease in forested area, increase in farmland, decrease in shrubland, decrease in water body, and increase in bareland. The general trend in 2024 was grassland < bareland < water body < farmland < buildup < shrubland < forest.

The result indicated that there was more degradation and accommulation impact over the paeriod studied. The study further revealed a positive increase in buildup between 2003 and 2018 as well as between 2018 and 2024; an indication of sustained development in the area. This is opposed to the changes in forested areas which decreased by 11.01 km^2 between 2003 and 2018, and 15.41 km^2 between 2018 and 2024; indicating that part of the forest was increasingly used for developmental activities in the area. Furher analysis revealed a sigificant increase in area covered by shrubs between 2003 and 2018 as well as between 2018 and 2024, while there was increase in water body between 2003 and 2018, and decrease between between 2018 and 2024.

CONCLUSION

Finding from the study indicated moderate levels of Pb, Ni, and Cr in the water, soil, and plant studied. Systematic physicochemical, instrumental, geospatial, and statistical analyses of the study area pointed to pollution and degradation of the area by anthropogenic contributions and natural factors. The elevated levels of some heavy metals at the Beach has challenging impact on human health and the environment. Findings revealed significant changes in the geophysical morphology of the area under study. Remotely sensed data analysed geospatially revelaed that in 2003, most of the area was covered with forest and the least significant coverage was bareland (167.31km^2) with the area of 0.66 square kilometer. It was discovered that between 2003 and 2024, forested and agricultural area decreased 202.55 square km to 146.33 square km, while buildup area increased from14.02 square km to 19.32 square km. The increased human settlement in the area the growth of human population and corresponding increase in anthropogenic contributions to environmental pollution and land degrdation in the area. Thus, the combination of conventional and space-based technologies to assess the level of water pollution and land degradation can enhance informed decision making for sustainable development. The study is a useful tool for the assessment of environmental degradation and identification land degradation hotspot. It provides a reliable database for further studies, informed decision making and sustainable development in Ibeno, Akwa Ibom State and Nigeria at large. Following the results obtained from the Ibeno Beach in Akwa Ibom State, there is a need for remediation of the beach and its environments. Best beach management practice should be adopted as a way of life in the routine running of the beach. Regular monitoring of compliance on relevance regulatory procedures on beach administration and management should be explored, more researches should be carried out ascertain the pollution level of Ibeno beach using multivariate techniques.

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