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IMPACT OF SAND MINING ON SOIL AND WATER QUALITY ALONG ADDO - BADDORE ROAD, AJAH, LAGOS STATE, NIGERIA

Ogungbe A.S[1*], Babatunde O.S[2], Alabi A.A[3] and Coker J.O[4]

[1*]Department of Physics, Lagos State University, Lagos, Nigeria
[2]Centre for Environmental Studies and Sustainable Development, Lagos State University, Lagos, Nigeria
[3]Department of Physics, Federal University of Agriculture, Abeokuta, Nigeria
[4]Department of Physics, Olabisi Onabanjo University, Ago-Iwoye, Nigeria

ABSTRACT: *Thick pile of well sorted sand of good construction grade exists along the bay of Addo-Baddore, Ajah axis of Lagos State, Southwest, Nigeria. This was responsible for the sitting of several sand mining depots along the shore axis of the area. This study was carried out to study the impact of sand mining on soil and water along this axis, with a view to ascertaining the level of degradation on the environment and groundwater contamination. Four locations were considered. They are: Blenco 1 (Active Mine), Blenco 2 (Abandoned Mine), Oke-Ira-Nla and Baddore. Laboratory analyses of water and sediments, as well as geophysical survey, using 2D Electrical Resistivity Imaging (Wenner) were used. Findings revealed high turbidity values that exceeded the NIS set standard of 5 NTU in all the locations. Pollution from fecal coliforms and heterotrophic bacteria existed in the groundwater within the region with values far above WHO and NIS set standard of 100 CFU/ml. Low resistivity value ranging from 2.59 Ωm to 106 Ωm, was observed at Blenco 1, Blenco 2 and Oke-Ira-Nla. This is an indication of degradation, unstable and erosion prone zone. At Baddore, a high resistivity value of up to 2807 Ωm was observed, indicating an un-degraded stable zone. This study highlights the call for awareness of all the stakeholders in the area for close monitoring of mining activities.*

KEYWORDS: Mining, Sand, Water Quality, Electrical Resistivity, Soil, Sediments, Turbidity

INTRODUCTION

The environment is man's immediate surrounding which he manipulates for his existence (NISP, 2010). It comprises air, land, water, natural resources, flora and fauna, and human beings. In the Environmental Impact Assessment (EIA) Decree, environment is defined as the components of the earth and includes: (i) Land, Water and Air including all layers of the earth; (ii) All organic and inorganic and living organisms, and (iii) The interacting natural systems that include components referred to in (i) and (ii) above (Loius and Smart, 1997).

The United Nations Report of the Conference on the Human Environment refers to man's environment as that which gives him physical sustenance and affords him the opportunity for intellectual, spiritual, moral and social growth (Safeguard Resources, 2001). This implies that both the naturally–occurring and human–induced components of the environment play inter-dependent roles in creating an enabling or a conducive arena for man's pursuit of healthy living and happiness.

Since the beginning of civilization, people have used stone, ceramics and later, metals found close to the Earth's surface. These were used to make early tools and weapons. The world is now faced with various environmental challenges such as global warming, acid rain, drought, flood, ozone layer depletion, and desertification; endanger species of which man is the major culprit. Concern for the environment has been from as early as the 13th century when reacting to the burning of coal in London because it was considered harmful to health. The king in 1273 prohibited the burning of coal in London (NISP, 2010). There are further concerns because the scale and nature of human activity may now be threatening the earth as a planet. For these reasons, protection of the environment has assumed greater dimensions. Exploration and exploitation of environmental resources such as minerals - gravel, sand, as well as crude oil otherwise known as "liquid gold", and metals, are all potential dangers to the environment.

Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt (Wikipedia, 2018). The main constituent of sand is silica (silicon dioxide) and is a non-renewable resource (Tariro, 2013).

Mining techniques can be divided into two (2) common excavation types i.e. Surface mining and Sub-surface (Underground) mining. Surface mining comprises 90% of the world's mineral tonnage output. This is also called open pit mining. Surface mining is removing minerals in formations that are at or near the surface e.g quarrying, strip mining etc. Underground mining consists of digging tunnels or shafts into the earth to reach buried depots (Wikipedia, 2018).

Rivers all over the world are under immense pressure due to various kinds of anthropogenic activities resulting from rapid urbanization, among which indiscriminate extraction of sand and gravel is most disastrous, as the activities threaten the river ecosystem (GreenFacts, 2018).

Sand mining results in the destruction of aquatic and riparian habitat through the large changes in the channel morphology. Impact includes bed degradation, bed coarsening, lowered water tables near streambed and channel instability (Kivuva, 2014). This physical instability may lead to undermining of bridges and other infrastructures inside the rivers. Also, the massive movement of truckload in and out of the active mining site generates extra vehicle traffic, causing air pollution and added stress to other road users.

Deep dredging can change local water depth significantly. It can also influence the hydrodynamics of the extracted site. Depending on the dimension of the dredging area, this can lead to temporary increase scouring, but also stratification in the pit is possible. With extraction depth, the chances of exposing sediment layers with different sediment composition than previous seafloor increases. Depending on the depth, location and dimension of the deep pit, oxygen depletion at the bottom of the pit is possible. Mining reduces the amount of food, shelter, and spawning and breeding habitat available for aquatic and terrestrial animals. It reduces the recreational and aesthetic values. All these leave their effects on the landscape (GreenFacts, 2018). Negative effects on the environment are unequivocal and are occurring around the world. The volume being extracted is having a major impact on rivers, deltas, coastal and marine ecosystems. Sand mining results in loss of land through river or coastal erosion, lowering of the water table and decreases in the amount of sediment supply (GreenFacts, 2018).

Nigeria began mining many decades before the arrival of the Europeans (Ahove, 2017). This was done through traditional methods with locally available technology. Gold, clay, iron, ore, tin, soda etc. were used in the body adornments, for the fabrication of weapons, tools, vessels, for construction and several other uses. The arrival of the British led to the increased varieties of minerals mined, and large-scale commercial mining commenced. Other minerals found in Nigeria are petroleum, coal, limestone, marble, and uranium.

In this study, we focus on extraction or mining of sand from the river along Addo-Baddore road. Addo-Baddore is a rapidly growing community that accommodates churches, shopping malls, gas stations, and commercial banks as well as various low-cost medium houses. The stretch of the road leads to developed and rapidly developing housing estates, a ferry service station (jetty) that conveys people to various parts and outskirts of Lagos. The entire stretch of the road is punctuated with dredging and sand mining depots.

First to be noticed along the route is the heavy vehicular traffic, the heaps of sand at various active mining stations. These active sand mining sites have local people as their immediate neighbors who are ignorant of or have adapted to the menace caused by the mining activities. There is constant repair of roads in the area as a result of erosion created by potholes from heavy trucks movements into and out of the sand depots. The vehicular traffic has caused so much loss of useful hours to the road users. Besides, beehive of mining businesses has attracted many traders whose wastes in form of litters, excreta, and oil spillage from spent oil are common sight. All these subjects the environment to constant pressure. Percolated sand from building foundations and road sub base are washed into the river. It is therefore imperative to study the impact of sand mining activities to the aquatic and lithospheric habitat on which the life of the inhabitants directly or indirectly depends upon.

MATERIALS AND METHODS

Description of Study Area

Ajah is situated in the Eti Osa Local Government of Lagos State, Nigeria. It is a fast-developing area. Addo –Baddore road is approximately 4 km within Ajah. It is currently the only access road to various developed and developing housing estates in the area. The study area is characterized with mixed economic activities – corporate entities, such as banks, religious centres, relaxation and recreation centres as well as open markets for sales of foodstuffs. Street trading, shopping malls, and lock up shops are common sight in the area. Being a riverine area, it is a settlement for the Ilajes who are known for fishing as a means of livelihood. Figure 1 shows the map of Ajah.

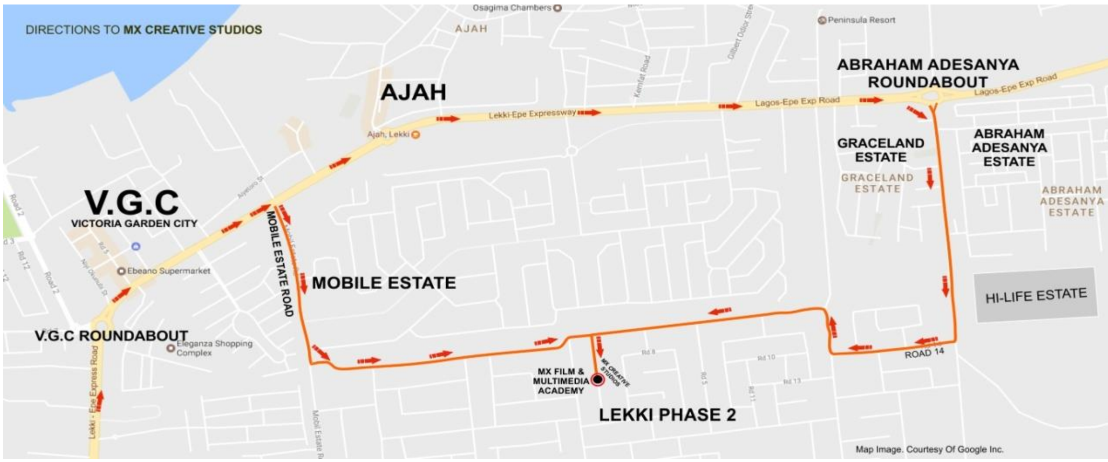

Figure 1: Map Showing Ajah

Site Accessibility and Geology of the Study Area

Ajah is a large neighbourhood in the Lekki area of Lagos. It spans from Victoria Garden City (VGC) down to Abraham Adesanya roundabout on the Lekki-Epe Expressway, and extends to places like Baddore, Addo, and Langbasa in its interior. It is one of the constantly developing places in the Lekki axis. It takes between 25 - 40 minutes to get to Victoria Island (V.I) from Ajah.

In the past, the area was known for heavy traffic. Motorists in the area commuting to and fro their various places of work faced severe traffic daily during the rush hour periods of the day. However, the recently commissioned flyover bridge has helped to significantly improve the traffic situation in the area (although there's still traffic in the evening, caused by the activities of traders and commercial bus drivers at the Ilaje Junction). There is the ever-busy Ajah market located off the Lekki-Epe Expressway. The Ajah market is a very popular market in Lekki where one can get items such as foodstuff, fruits, clothes and other household items.

Addo Road is a major road in the Ajah community, with the entrance popularly known as Ajah Bus Stop (formerly Ajah Roundabout). It is the link road to other parts of Ajah, like Baddore and Langbasa. One remarkable thing along the Addo Road is the Olumegbon Palace located just after Ajah-Bus Stop. There's the S-Forte Estate on the left side of the road and Kays Court on the right side. There are also several business activities along the road. However, the road is very narrow and poorly maintained. As a result, on a busy day, traffic on the road can be unbearable.

The Baddore area of Ajah boasts a tarred, well-demarcated central road, with poorly maintained drainage channels on both sides. One notable thing is the NIPOST office located along the road. There's also Cooperative Villa Estate located within the area. There are several other estates in the area such as: Royal Palm Estate, Seaside Estate, Common Wealth Estate, Rockstone Ville Estate, Allied Gardens Estate, Peaceville Estate located on the right side of the road; while to the left are: Dockville Estate, Palm Crescent Estate, Vina Estate, Platinum Estate, Mega Estate, Greenville Estate and Silver Point Estate.

During the recent Lekki flood, the Ajah areas were some of the places that were affected the most. The area is close to the river and has a naturally lowland that is slightly above sea level. The drainage channels within the area are always blocked as usual and do not flow freely.

The geology falls within the extensive Dahomey Basin in Southwestern Nigeria. It is underlain by sand, sandy clay and lignite, with vegetated freshwater deposits of mainly Recent-Quaternary alluvium above the Ilaro Formation (Malomo and Oloruniwo, 1983; Onwuka, 1990). Figure 2 shows the map of the study Area (Addo – Baddore)

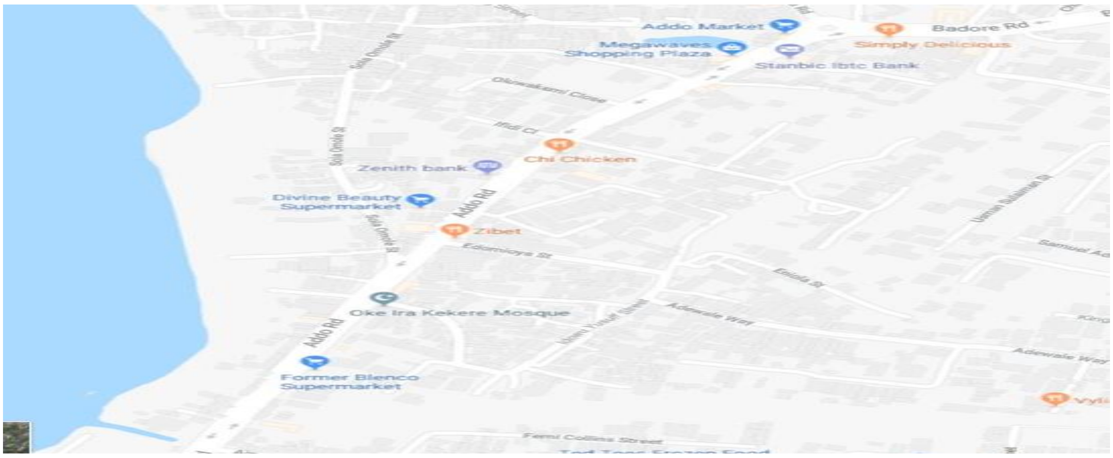

Figure 2: Map of the study Area (Addo – Baddore)

Data Acquisition and Field Equipment

Geophysical exploration is detecting stratigraphic rocks, geological structure and other geological conditions through the study and observation of changes in a variety of geophysical fields. The survey was carried out using 2D Electrical Resistivity Imaging and ABEM Terrameter SAS 1000 was used for data acquisition.

Eight profiles were established for the electrical resistivity method, and each had a length of 200 m. Two profiles were established in each location. The electrode spread (Wenner array configuration) for data collection along the profiles in each of the locations used electrode spacing of 10 m, 20 m, 30 m and 40 m.

In order to determine the impact of sand mining within the area, laboratory analyses were carried out on both water and sediment samples. 15 water samples and 12 sediments were collected at random from the locations – Blenco, Oke –Ira, Lagos State Water Corporation (LSWC), Baddore; as well as a servicing borehole at Blenco. All sample containers and equipment were thoroughly prepared and cleaned before use. Sample containers were washed, rinsed with deionized water, drained and tightly packed until used. They were carefully drawn and stored in clean sample bottles, until analyses. Figure 3 shows the composite Base Map for all the Four Study Locations.

Figure 3: Composite Base Map for all the Four Study Locations

Data Analysis

The raw field data were processed using RES2DINV for 2D resistivity method. This is a window-based computer program that automatically determines a two-dimensional (2D) resistivity model for the subsurface data obtained from electrical survey. The forward modelling subroutine is used to calculate the apparent resistivity values. The inverse procedure is based on an iterative smoothness-constrained least-squares algorithm. This computer program uses a smoothness constrained non-linear least-squares optimization inversion technique to convert measured apparent resistivity values to true resistivity values and plot them in cross-sections. The inversion process removes geometrical effects from the pseudo section and produces an image of true depth and true formation resistivity. The program creates a resistivity cross-section, calculates the apparent resistivity for that cross-section, and compares the calculated apparent resistivity to the measured apparent resistivity. The iteration continues until a combined smoothness constrained objective function is minimized.

Analysis of Sediments and Water

After the sediment samples have been collected from the dredging sites, they were taken to the laboratory for analysis. The samples were air dried and were sieved to pass through to 20 mm sieve. Representative sub-samples of the sieved sediments were leached with Nitric/Hydrochloric acid (1:3) solution, employing standard digestion procedure. Heavy metal levels were analyzed with an atomic absorption spectrometer.

A well-mixed sub-sample of the water samples was digested with 6M HCl, prior to analysis of the heavy metals by atomic absorption spectrometry. Spectrophotometric measurements were made on filtered sub-samples.

Physicochemical and Microbiological Analyses

a. **pH and Temperature of Water and Sediment Samples**

Combination pH Electrode Method

pH of the water and sediment samples were determined, in-situ, on aliquot of unfiltered water, and on a sub-sample of the sediment sample, using a combination pH electrode of a pH meter (HM Digital)

b. **Turbidity**

Turbidimetric Method (ISO 7027)

Turbidity of the water samples was determined using a turbidity meter (HACH 2100Q), that measures the ratio of the primary nephelometric light scatter signal to the transmitted light scatter signal.

c. **Electrical Conductivity**

Electrical conductivity was determined by potentiometric method, using HACH multi-parameter conductivity meter (HQ40d) in the EC mode.

d. **Total Dissolved Solids (TDS)**

Total Dissolved Solids was determined by potentiometric method, using HACH multi-parameter conductivity meter (HQ40d) in the TDS mode.

e. **Salinity**

Salinity was determined by potentiometric method, using HACH multi-parameter conductivity meter (HQ40d) in the salinity mode.

f. **Acidity**

Acidity of unfiltered water samples was determined by the burette titration method. An aliquot of the test sample was titrated with standard alkali. The acidity was determined using phenolphthalein indicator.

$$\text{Acidity (mg/L as } CaCO_3) = \frac{(\text{Titre (ml) x 50000 x Molarity of Alkali})}{\text{Sample Volume (ml)}}$$

g. **Alkalinity**

Total Alkalinity of unfiltered water samples was determined by the burette titration method. An aliquot of the test sample was titrated with standard acid. The total alkalinity was determined using phenolphthalein and bromo-cresol green indicators, respectively. The alkalinities were calculated as follows:

$$\text{Total Alkalinity (mg/L as } CaCO_3) = \frac{(\text{Titre (ml) x 50000 x Molarity of Acid})}{\text{Sample Volume (ml)}}$$

h. Total Hardness

Total hardness was determined by the burette titration method. An aliquot of the test sample was titrated (at pH 10) with standard 0.01M EDTA titrant, using eriochrome Black-T as end-point indicator. The total hardness was determined as follows:

$$\text{Total Hardness (mg/L as } CaCO_3) = \frac{(\text{Titre (ml) x } 2500)}{\text{Sample volume (ml)}}$$

i. Dissolved Oxygen (Lamotte; Direct Reading burette titration Method)

Dissolved oxygen was determined by burette titration method wherein, DO was fixed in the field with subsequent titration of iodine with thiosulphate, using starch as indicator.

j. Biochemical Oxygen Demand

Direct Measurement (HACH Method 8157)

Sample initial and final dissolved oxygen, following incubation at 20°C, in the dark was determined with a DO meter equipped with an amperometric sensor.BOD was then determined as the difference between the initial and final DO.

k. Sulphate

Sulphate was determined by turbidimetric method, in which an aliquot of sample filtrate that passed through 0.45 µm membrane filter was reacted with barium chloride (HACH SulfaVer 4 reagent powder). The amount of turbidity in test solution is proportional to sulphate concentration and was determined using HACH DR 3900 Direct Reading spectrophotometer.

l. Nitrate

Cadmium Reduction Method (HACH 8039)

Cadmium metal reduces nitrates in the sample to nitrite. The nitrite ion reacts, in acidic medium, with sulfanilic acid to form an intermediate diazonium salt. The salt couples with gentisic acid to form an amber colored solution. The Nitraver 5 contains the test reagents in a single powder formulation. Test measurement is carried out at 500 nm using HACH DR 3900 Direct Reading spectrophotometer.

m. Chloride

Burette Titration Method

Chloride was determined in unfiltered water samples by burette titration. An aliquot of the test sample was titrated with standard 0.014M silver nitrate titrant, with potassium chromate as end-point indicator. The chloride concentration was calculated as follows:

$$\text{Chloride (mg/L)} = \frac{(\text{Titre (ml) x 35450 x molarity of titrant})}{\text{Sample Volume (ml)}}$$

n. Chemical Oxygen Demand

COD was determined by a closed reflux, colorimetric method, in which 2 ml of a homogenous mix of the sample was digested with dichromate/sulfuric acid reagent at 150 ^{0}C for 2h. COD was determined in the digested using HACH DR 3900 Direct Reading spectrophotometer.

o. Total Suspended Solids

Gravimetric Method (SM 2540-D)

Suspended solid was determined by gravimetric methods, after drying (103-105^{0}C) the residue, following the filtration of an aliquot of the sample.

p. Phosphate (Orthophosphate)

Ascorbic Acid Method (Hach Method 8048)

Orthophosphate reacts with molybdate in an acid medium to produce a mixed phosphate/molybdate complex. Ascorbic acid then reduces the complex to an intense blue color. Hach PhosVer 3 powder pillow contains the test reagents. Measurement is made at 880 nm, or at 610 nm, using HACH DR 3900 Direct Reading spectrophotometer.

q. Metals (Cd, Cu, Fe, Pb, Zn)

The metals were determined on samples digested in acid medium, and then analyzed by atomic absorption spectrometry. Test results were validated by multi-element calibration standards.

RESULTS AND DISCUSSION

Results and Discussion of 2D Electrical Resistivity Survey

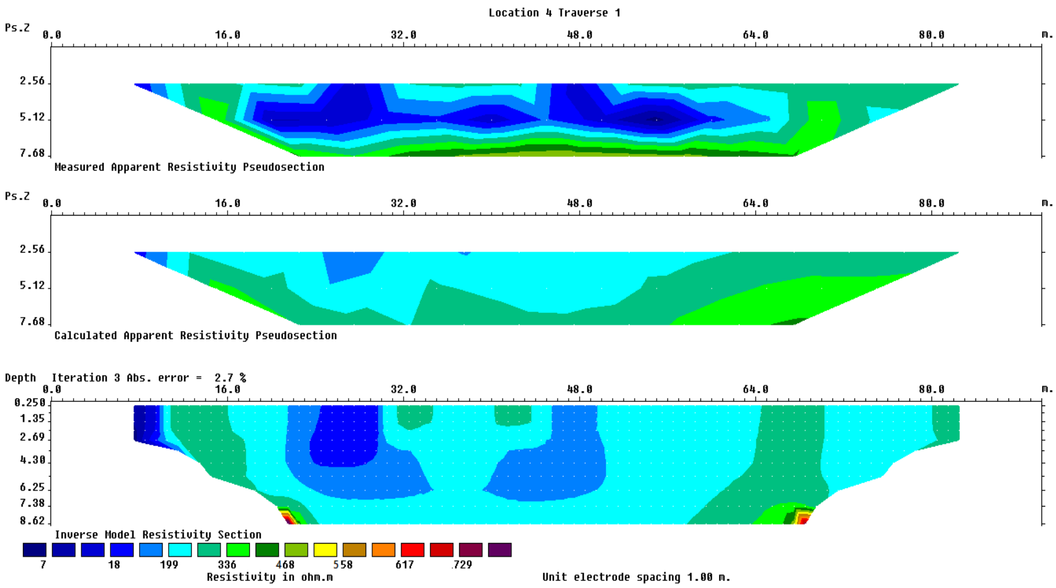

Figure 4a: Result of 2D Inversion of Profile 1 at Blenco 1

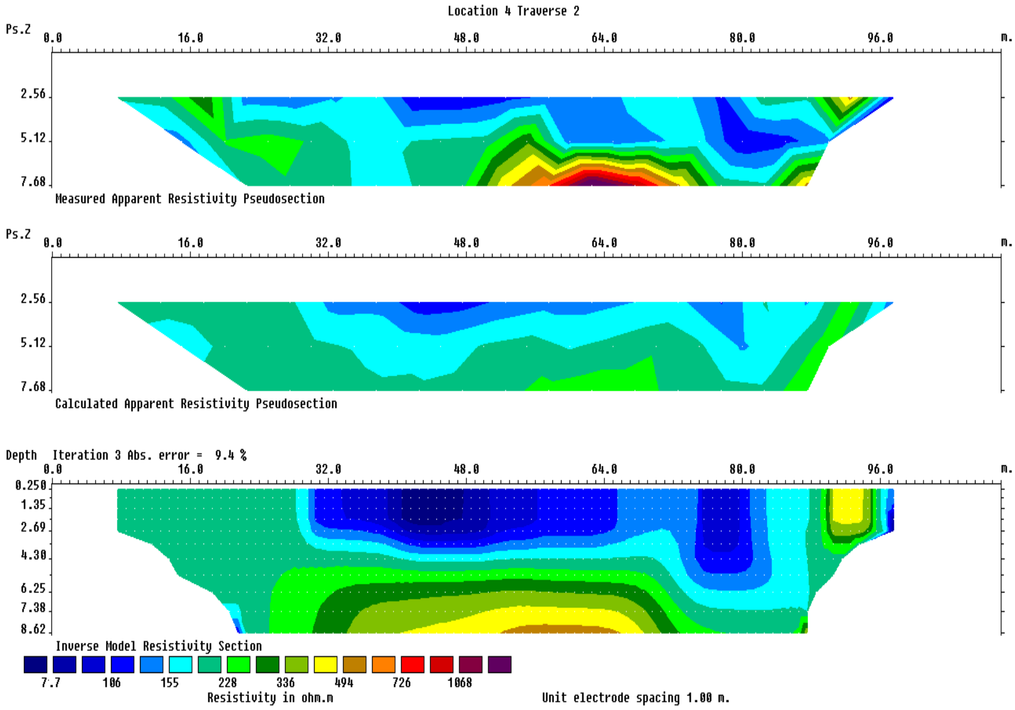

Figure 4b: Result of 2D Inversion of Profile 2 at Blenco 1

For profile 1 at Blenco 1**,** the low electrical resistivity zone depicts resistivity values that range between 7 Ωm and 199 Ωm. This extends in depth from the surface up to about 7.4 m and stretches from 21.5 m to 30 m along the profile line. This was also observed at 37.5 m to 41.5 m and at 7.5 m to 10 m but to a depth of 3.5 m. Some other regions along the profile with relatively higher resistivity value between 199 Ωm and 460 Ωm mostly from 41.5 m to about 82 m and to a depth of 8.62 m from the surface were also observed. These show relatively stable zones. The profile line is parallel to the shoreline.

The low resistivity region for profile 2 extends from 29 m to 82 m along the profile with resistivity value ranging from 7.7 Ωm to 106 Ωm and to a depth of between 5.0 m to 6.5 m. This transverse line is perpendicular to the shoreline and the later part falls inward the seashore. This region reflects an unstable, erosion prone zone and it is inward the seashore where active mining is said to be taking place. Underlying this low resistivity is a zone of relatively higher resistivity 336 m to 494 m and from depth of between 5.0 m to 8.62 m. Other regions along the profile with resistivity between 155 Ωm and 228 Ωm from 7.5 m to 28 m along the profile and to a depth of 8.62 m were also observed. These show relatively stable zones.

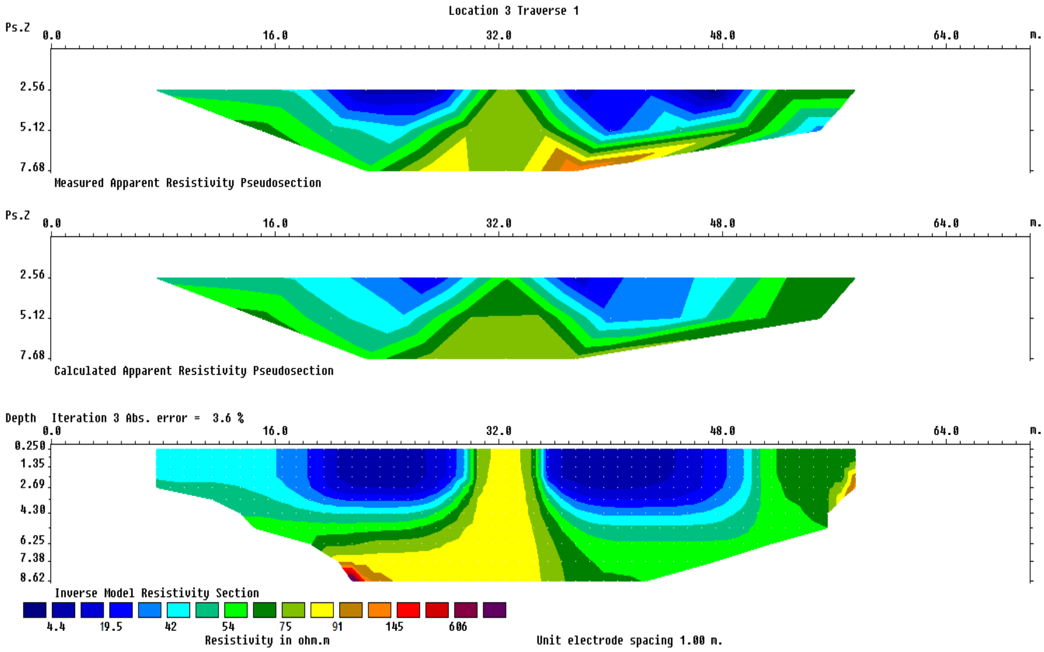

Figure 5a: Result of 2D Inversion of Profile 1 at Blenco 2

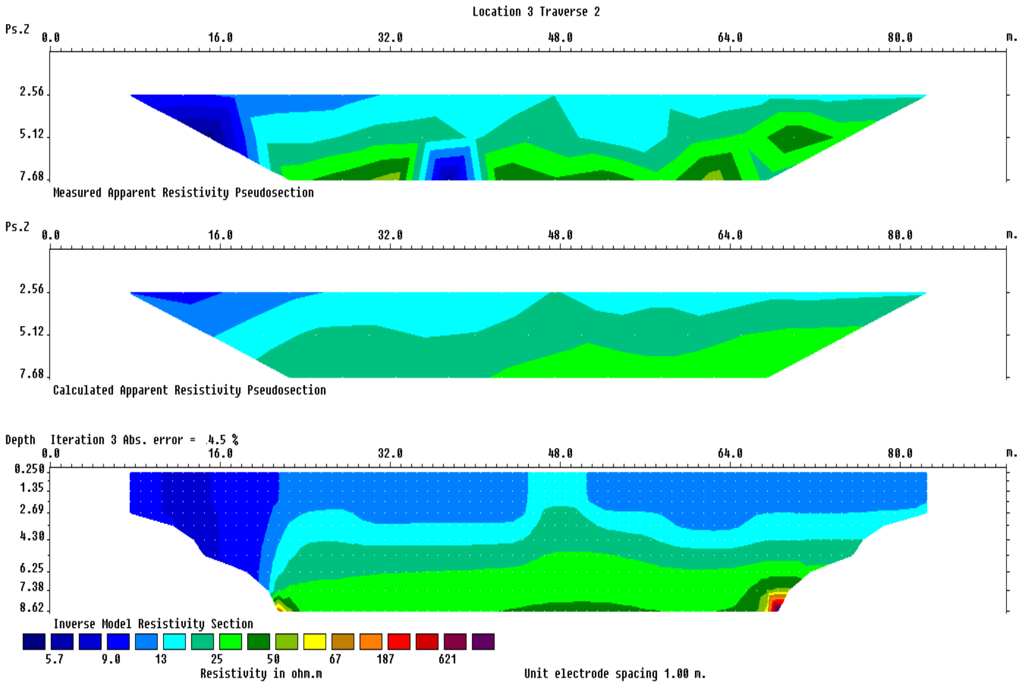

Figure 5b: Result of 2D Inversion of Profile 2 at Blenco 2

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For Profile 1 at Blenco 2, the electrical resistivity values range from 4.4 Ωm to 606 Ωm. The low resistivity regions of the profile start from 16 m extending to about 30 m along the surface with resistivity value in the ranging from 4.4 Ωm to 19.5 Ωm. The low resistivity value region extends in depth up to about 4.30 m. Along the profile, from 35 m to 48 m stretch also depicts region of low resistivity, ranging from 4.4 Ωm to 19.5 Ωm and to a depth of about 5.4 m. The profile line is perpendicular to the shoreline and the latter part falls inward along the coastline. That is, low resistivity region exists along the coastline where active mining had taken place.

The low resistivity region for Profile 2 is a stretch from 8 m to 45 m and from 48.5 m to about 82 m with resistivity ranging from 5.7 Ωm to 13 Ωm. This extends to a depth of about 7.38 m at 20 m stretch and to lower depths at other points along the surface. The profile line is perpendicular to the shoreline. That is, low resistivity region exists along the coastline where active mining had taken place.

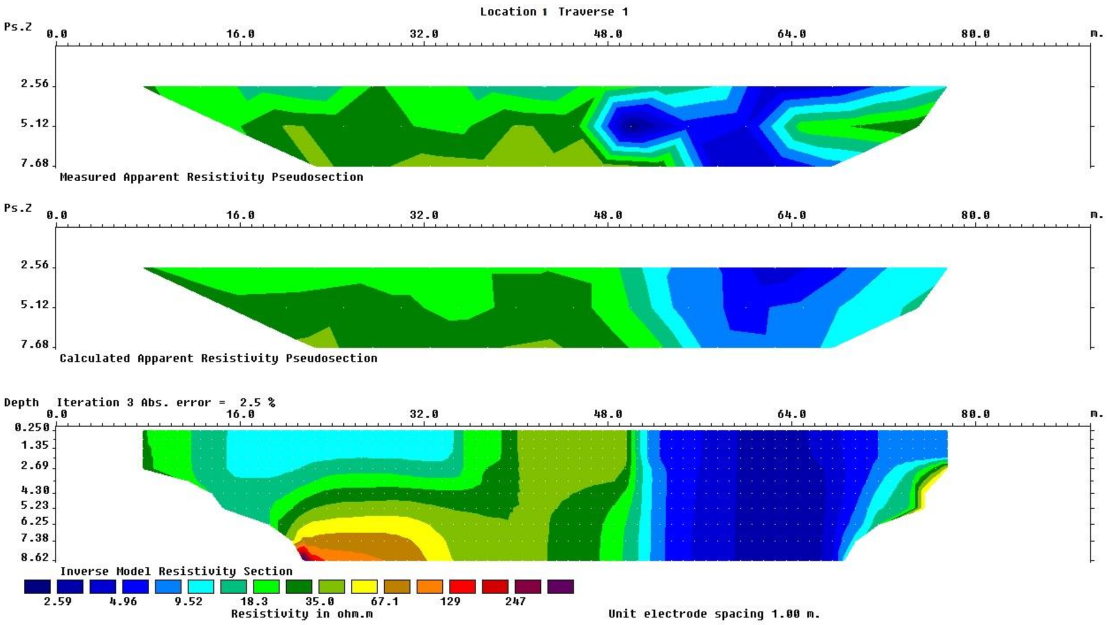

Figure 6a: Result of 2D Inversion of Profile 1 at Oke-Ira Nla

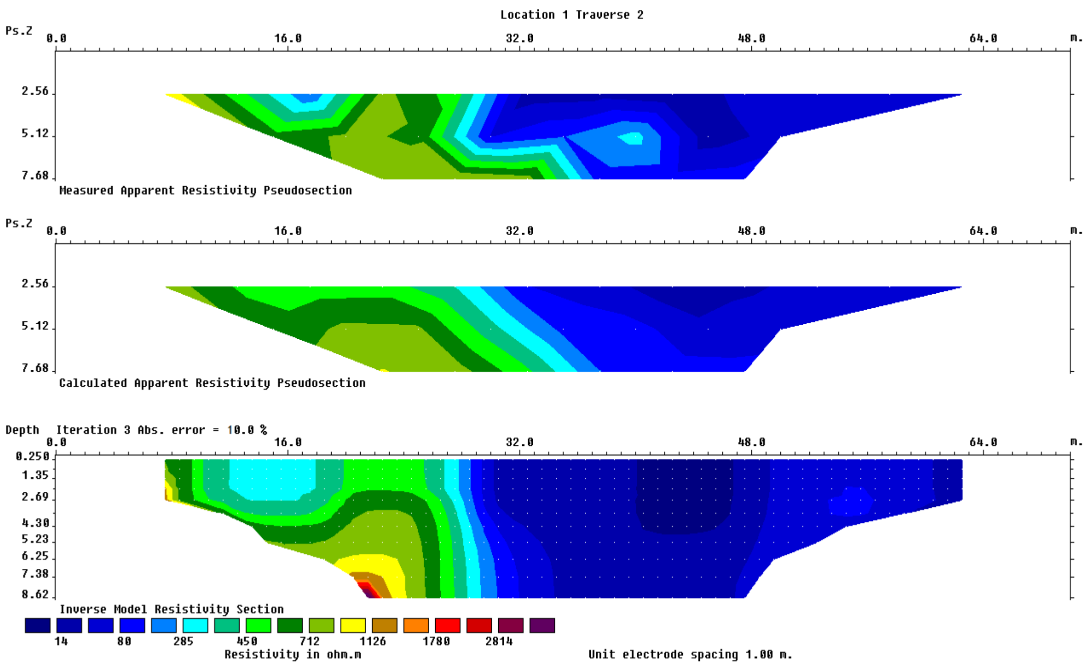

Figure 6b: Result of 2D Inversion of Profile 2 at Oke-Ira Nla

For Profile 1 at Oke-Ira Nla, the low resistivity region forms an inclusion towards the eastern flank of the profile starting from about 48 m extending to about 80 m with resistivity of 2.59 Ωm to 9 Ωm. The low resistivity value region extends in depth up to about 9 m. The traverse line is perpendicular to the shoreline, making the later part of the traverse falls at the continental shelf of the ocean. This literarily means that the low resistivity region falls directly on the continental shelf where active mining is said to have taken place. The low resistivity region for Profile 2 starts from around 30 m and extends to 48 m along the traverse line up to about 9 m depth with resistivity of < 14 Ωm. A relatively low resistivity region of 88 Ωm was also observed from 48 m to 60 m stretch along the profile.

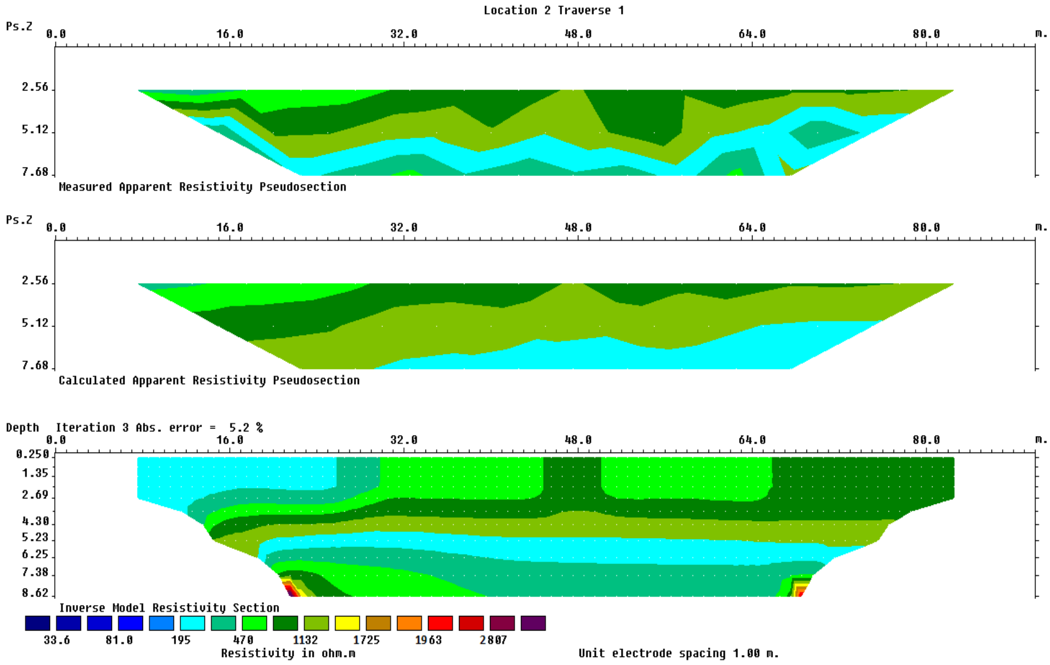

Figure 7a: Result of 2D Inversion of Profile 1 at Baddore

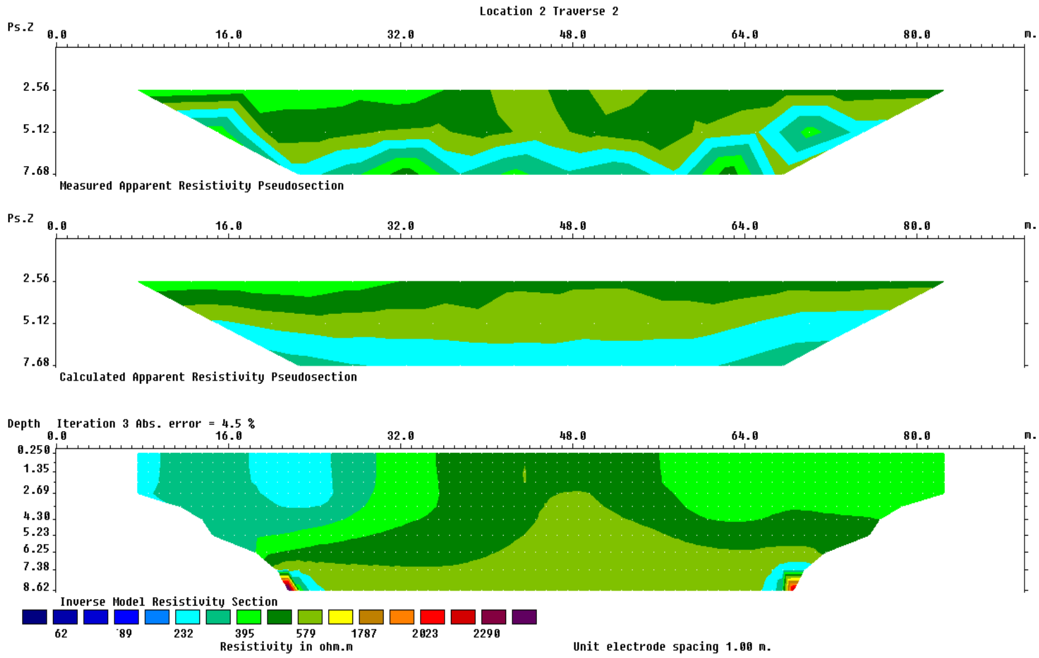

Figure 7b: Result of 2D Inversion of Profile 2 at Baddore

Profile 1 at Baddore is approximately 4 km away from Addo and is perpendicular to the shoreline. The electrical resistivity ranges from 33.6 Ωm to 2807 Ωm. Most section of the profile from the surface up to 9 m depth and stretching to 80 m along the profile is characterized with resistivity value ranging from 195 Ωm to 1132 Ωm. This is an indication of relatively stable zone.

Profile 2 is parallel to the shoreline. Most section of the profile from the surface up to 9 m depth and stretching to 80 m along the profile is characterized with resistivity value ranging from 232 Ωm to 579 Ωm. This region appears to be relatively stable, undisturbed or un-degraded with low resistivity region virtually nonexistent. This was used as the reference point and there was no mining activity here. It means that the location has more competence or is in an undisturbed shoreline, thus, making it more stable with high resistance to erosion and other environmental impacts.

Table 1: Results of Analysis of Water Samples

S/N	PARAMETER	Station 1 BLENCO 1 (Active Mine)	Station 2 BLENCO 2 (Abandoned Mine)	Station 3 Jetty 1- Oke –Ira Nla	Station 4 Jetty 2 – Baddore	WHO (2011)	NIS (2007)
A	**Physicochemical Tests**						
1	Temperature (^{0}C)	29.8	30.4	30.6	29.3	NG	NG
2	Appearance	-	-	-	-	Colorless	Colorless
3	Odour	N/O	N/O	N/O	N/O	N/O	N/O
4	pH °C	7.26	6.42	7.15	7.40	NG	6.50-8.50
5	Colour (TCU)	8.1	9.3	11.6	11.9	NG	15.0
6	Electrical Conductivity (µS/cm)	17550.0	17360.5	16880.1	7190.3	NG	1000.0
7	Total Dissolved Solids (mg/L)	10705.1	10589.0	10296.7	4026.4	NG	500.0
8	Total Suspended Solids (mg/L)	26	41	188	28	NG	NG
9	**Turbidity (NTU)**	**17.65**	**35.30**	**109.00**	**14.94**	**NG**	**5.00**
10	Salinity (ppt, at 25°C)	9.90	9.82	9.51	3.85	NG	NG
11	Dissolved Oxygen (mg/L)	5.62	5.05	4.96	4.12		
12	Biochemical Oxygen Demand (mg/L)	11	18	23	31		
13	Chemical Oxygen Demand (mg/L)	83	89	97	114		
14	Total Alkalinity (mg/L; as $CaCO_3$)	108.4	116.3	118.7	121.1	NG	NG
15	Acidity (mg/L; as $CaCO_3$)	7.5	7.9	8.0	8.8	NG	NG
16	Total Hardness (mg/L; as $CaCO_3$)	1750.0	1748.2	1744.1	589.3	NG	150.0
17	Calcium (mg/L)	102.80	101.03	99.10	35.31	NG	NG
18	Magnesium (mg/L)	361.21	362.10	360.08	121.11	NG	0.200
19	Phosphate (mg/L; PO_4^{3-})	0.08	0.45	1.24	0.46	NG	NG
20	Nitrate (mg/L; NO_3^-)	1.77	1.95	2.29	3.05		
21	Sulphate (mg/L; SO_4^{2-})	664.0	640.3	653.0	217.0		

22	Chloride (mg/L)	5061.3	5053.4	5050.0	1705.1		
23	Iron (mg/L)	0.114	0.102	0.422	0.123		
24	Copper (mg/L)	0.0006	0.0005	0.0011	0.0015		
25	Cadmium (mg/L)	0.0007	0.0006	0.0009	0.0010		
26	Lead (mg/L)	0.0014	0.0020	0.0012	0.0018		
27	Zinc (mg/L)	0.0150	0.0014	0.0070	0.0018		
B	**Microbiological Tests**						
1	Total Heterotrophic Bacteria (*CFU/100mL)	**1.2**	**3.7**	**5.1**	**9.3**		
2	Fecal Coliforms (CFU/100mL)	**4**	**62**	**5**	**11**		
3	E. coli (CFU/100mL)	ND	ND	ND	ND		

Note: N/O = Not Objectionable
L/brown = light brownish
THB = ***CFU/100mL x 10^3**
Coliform = **CFU/100mL x 10^1**
E. coli = ***CFU/100mL x 10^1**
ND = Not Detected

Table 2: Results of Analysis of Borehole Water Samples

S/N	PARAMETERS	LASG Water Corporation	Borehole Opposite Station 1	WHO (2011)	NIS (2007)
A	**Physicochemical Tests**				
1	Temperature (^{0}C)	32.5	29.6	NG	NG
2	Appearance	L/brown	L/brown	Colorless	Colorless
3	Odour	N/O	N/O	N/O	N/O
4	pH °C	6.52	7.70	NG	6.50 - 8.50
5	Colour (TCU)	7.2	6.7	NG	15.0
6	Electrical Conductivity (µS/cm)	134.6	474.0	NG	1000.0
7	Total Dissolved Solids (mg/L)	75.1	263.0	NG	500.0
8	Total Suspended Solids (mg/L)	38	22	NG	NG
9	**Turbidity (NTU)**	**17.89**	**10.27**	**NG**	**5**
10	Salinity (ppt, at 25°C)	0.08	0.31	NG	NG
11	Dissolved Oxygen (mg/L)	-	-		
12	Biochemical Oxygen Demand (mg/L)	-	-		
13	Chemical Oxygen Demand (mg/L)	-	-		

14	Total Alkalinity (mg/L; as $CaCO_3$)	86.9	98.5	NG	NG
15	Acidity (mg/L; as $CaCO_3$)	16.4	12.3	NG	NG
16	Total Hardness (mg/L; as $CaCO_3$)	15.2	24.7	NG	150
17	Calcium (mg/L)	0.93	1.44	NG	NG
18	Magnesium (mg/L)	3.12	5.05	NG	0.20
19	Phosphate (mg/L; PO_4^{3-})	1.01	0.18	NG	NG
20	Nitrate (mg/L; NO_3^-)	1.51	1.49	50.00	50.00
21	Sulphate (mg/L; SO_4^{2-})	5.6	21.1	NG	100.0
22	Chloride (mg/L)	44.2	165.0	NG	250.0
23	Iron (mg/L)	0.302	0.101	NG	0.300
24	Copper (mg/L)	0.0002	0.0003	2.0000	1.0000
25	Cadmium (mg/L)	<0.0005	<0.0005	0.0030	0.0030
26	Lead (mg/L)	<0.001	<0.001	0.010	0.010
27	Zinc (mg/L)	0.0031	0.0120	NG	3.0000
B	**Microbiological Tests**				
1	**Total Heterotrophic Bacteria (CFU/100mL)**	**245**	**302**	**100**	**100**
2	Fecal Coliforms (CFU/100mL)	ND	ND	0	0
3	E. coli (CFU/100mL)	ND	ND	0	0

Note: N/O = Not Objectionable
L/brown = light brownish
ND = Not Detected
NG = No Guideline Value, based on health considerations

Table 3: Results of Analysis of Sediment Samples

S/N	PARAMETER	Station 1 BLENCO 1 (Active Mine)	Station 2 BLENCO 2 (Abandoned Mine)	Station 3 Jetty 1-Oke –Ira Nla	Station 4 Jetty 2 – Baddore
1	Temperature (°C)	29.4	29.5	29.4	29.5
2	pH at 25°C	7.33	6.63	7.01	7.46
3	Total Organic Carbon (%)	1.4	0.9	2.5	3.9
4	Phosphate (mg/kg; PO_4^{3-})	11.20	9.63	3.03	7.10
5	Nitrate (mg/kg; NO_3^-)	36.22	22.10	16.30	16.01
6	Sulphate (mg/kg SO_4^{2-})	2.4	1.1	2.6	3.0
7	Iron (mg/kg)	9.52	5.08	32.11	47.72
8	Copper (mg/kg)	0.07	0.05	0.13	0.11
9	Cadmium (mg/kg)	0.12	0.16	0.21	0.24
10	Lead (mg/kg)	0.06	0.04	0.10	0.09
11	Zinc (mg/kg)	0.521	0.582	0.598	0.942

CONCLUSION

Sand mining has adversely affected the land and water quality along Addo-Baddore road. The study area is now characterized with potholes. This is due to heavy vehicular movements caused by mining activities along the road. There are pit lakes created along the shoreline at the abandoned sand mine areas. The surroundings of active mines are characterized with massive bush clearing, sand dunes, land pollution from used oil, disturbed river beds and change in the geomorphology which are indices of environmental deterioration. Though the community is benefiting from the added economic value such as job creation, cheap sand for rapid building developments, but the impacts far exceed the current and long run consequences from the environmental degradation and deterioration.

Findings revealed high turbidity values that exceeded the NIS set standard of 5 NTU in all the locations. Pollution from fecal coliforms and heterotrophic bacteria existed in the groundwater within the region with values far above WHO and NIS set standard of 100 CFU/ml. This is an indication of ideal condition for breeding of pathogens. Also, the extent of degradation not captured by laboratory analysis was reflected by the geophysical survey. That is, the effect is beyond the surface but hidden long run consequence from altered geomorphology of the entire environment. Low resistivity value ranging from 2.59 Ωm to 106 Ωm, was observed at Blenco 1, Blenco 2 and Oke-Ira-Nla. This is an indication of degradation, unstable and erosion prone zone. At Baddore, a high resistivity value of up to 2807 Ωm was observed, indicating an un-degraded stable zone. Hence, the geophysical survey depicted the adverse effect of sand mining in the area. This study has highlighted the call for awareness of all the stakeholders in the area for close monitoring of mining activities.

Therefore, considering the aforementioned results, it is justifiable that a “stop work order” by the Lagos State Government be given to sand miners in the area.

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