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RESEARCH ARTICLE

ASSESSMENT OF SEAWATER FLUX AND ITS IMPACT ON AYETORO COASTAL COMMUNITY OF ONDO STATE, NIGERIA

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ABSTRACT

Climate change impact had given rise to incessant flooding exacerbated by high tidal fluctuations, sea level rise and its accompanying negative impacts such as land degradation and seawater incursion into freshwater sources. Hence, the need to assess the hydrochemistry and anthropogenic pollutants in water, sediment and representative fish samples of Aiyetoro coastal waters. Thirteen sampling stations (including 2 groundwater stations and 3 control stations) were selected to determine the concentration and spatial distributions of hydro-chemical characteristics and heavy metals concentrations. The results of the ionic concentrations (e.g., Calcium Ca^{2+},Magnesium Mg^{2+},Sodium, Na^{+}, Potassium K^{+}, Nitrate NO_3^{-}, Phosphate PO_4^{3-}, Sulphate SO_4^{2-} and Chloride Cl^{-}) further showed higher values that exceed the World Health Organization (WHO) standard, Federal Environmental Protection Agency (FEPA), and Federal Ministry of Environment (FEMENV) permissible limit for portable water and coastal water for marine life sustainability. The result further affirms the high impact of land degradation and saline water intrusion. Low pH, Dissolved Oxygen (DO) at some stations indicate increased anthropogenic activities. Heavy metal analysis further showed high Lead (Pb) concentrations in water, Copper (Cu), Manganese (Mn), Chromium (Cr) in sediment and Cu, zinc (Zn), Pb, cadmium (Cd), cobalt (Co) and Nickel (Ni) in representative fish samples. This study establishes that sea-level rise, land degradation, flooding and human-induced anthropogenic activities have negatively impacted Aiyetoro community, hence an urgent need for bioremediation.

INTRODUCTION

Increased urbanization and population, climate change and other anthropogenic activities have severe consequences on the ecosystem stability of the coastal environment and consequently, the health of the communities located along the coast. (Manuta *et al*., 2005; Schipper *et al*.,2006; *Benitez-Lobez. et al*., 2010; Adagbasa *et al*.,2014). Global warming accompanied with sea level rise, increased precipitation and change in salinity regime have greatly altered the ecosystem dynamics of the planet, earth. In the past few decades economic loss due to natural disasters and flooding had become more pronounced among the coastal communities of Nigeria (Awosika *et al*., 1993; Bonde *et al*., 2012; Marsh *et al*., 2017). Managing and mitigating the unfolding changes, their impacts and implications for the environment and society require improved scientific understanding of past and present trends and of the inertia and feedbacks in both natural and human systems (Ikuhoria *et al*., 2012; Adetoro and Akanni, 2018).There is thus a pressing need to focus the best scientific knowledge that are capable of minimizing the threats to human and aquatic lives. Aiyetoro, a coastal fishing community, in Ondo state, Southwest of Nigeria is known for its richness in seafood like, crabs, periwinkles, crayfish and diverse species of fish. Therefore, land degradation and seawater incursion in the community is a national and global food security and health concern (Olatunji-Ojo *et al*., 2019).

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Land degradation and displacements as a result of high-water pressure, tides, waves and the accompanying effect of saline-water intrusions can lead to the occurrence of high economic loss due to the reduction of agricultural products such as fishing, which is the primary occupation of the Aiyetoro community. Over 30 per cent of land in Ayetoro community and its environs had been abandoned and approximately 2km distance along the Ilaje coastal waters had already been affected by seawater intrusion Additionally, there are reported cases of human-induced activities arising from marine transportations, oil exploration, local and international petroleum marketing, pipeline vandalization and seepages, and illegal sand mining activities in the Aiyetoro coastal waters. Residential and domestic sewage discharges (which is also a common phenomenon in Aiyetoro community) tend to trigger a high rate of flooding, and eventual sea-level rise, as a minor influence. Temporal and spatial variation of physicochemical characteristics of surface and groundwater water bodies and sediments could be obtained by determining the magnitude of salinity (SAL), electrical conductivity (EC), total dissolved solids (TDS), turbidity (TURB), dissolved oxygen (DO) and others. Hydro-chemical characteristics such as cations (Sodium (Na^{+}), potassium (K^{+}), calcium (Ca^{2+}), magnesium (Mg^{2+}), anions / nutrients (sulphate (SO_4^{2-}), nitrate (NO_3^{-}), phosphate (PO_4^{3-}), and chorine (Cl^{-}) and the metal (e.g., Mn, Pb, Cd, Ni, Cu, Zn, Co and Cr) loading/pollution arising from human-induced anthropogenic activities (e.g., marine transportations, oil exploration, local and international petroleum marketing, pipeline vandalization and seepages, and illegal sand mining activities) are also strong indicators of pollution level. Selected fish samples were also analyzed for the impact of the

aforementioned anthropogenic pollutants. Previous studies on the Ilaje coastal waters (Adesina and Ogunseiju, 2017; Olatunji-Ojo *et al*., 2019; Ukelina *et al*., 2019) showed high concentrations of heavy metals (Pb, Cu and Zn, Fe and Mn) in sediments above the permissible limit.

Surprisingly, there is no available information on the integrated investigations of the hydro-chemical characteristics of surface and groundwater samples, metal accumulations in water, sediment and fish samples of the Aiyetoro coastal waters. The study aims to understand the impact of seawater incursion and the accompanying flooding, land degradation on the human and marine lives in the Aiyetoro community, and probable recommendation, suggestions and remediation processes.

Meterials and methods

Study Area: Aiyetoro is in Ilaje local government area in Ondo state and shares boundaries with Ikale by the North, Ijebus by the West, Itsekiri by the East, the Atlantic Ocean by the South with the Apoi and Arogbo Ijaw to the North East. It is located within longitude 5.166667˚E and latitude 7.366667˚N. Aiyetoro community is a settlement in the Ugbo Kingdom which is considered as the major Kingdom in Ilaje (Adekulne, 2016). Aiyetoro is a Yoruba name indicating a calm and settled world (Gbadamosi, 2016).

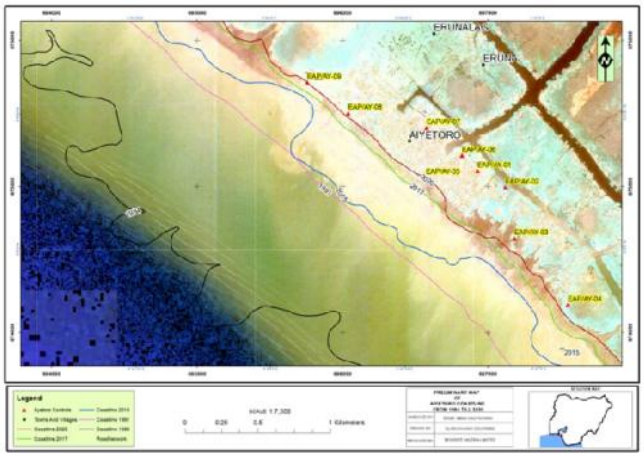

Fig. 1. Map of Study Area

METHODOLOGY

Eight sampling points (ST1…ST8) were selected at about 500m-1km into the sea and three control points (CTR1,2,3) were chosen away from the anthropogenic prone areas and lastly Samples of groundwater (BR1,2) used by the community dwellers as a source of drinking water and groundwater. Sediments and fish samples were also collected from selected stations for further analysis. Water temperature, pH, turbidity, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS) and salinity (SAL) were measured in-situ at every sampling station with Horiba U-52 multi-water parameters.

Water samples meant for heavy metal analysis were kept in pre-cleaned 0.5-litre plastic containers and acidified with 2 to 3 ml of nitric acid (HNO_3) to ensure that the respective ions remain in solution pending chemical analysis. Water samples meant for cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) and anions (SO_4^{2}, NO_3^-, PO_4^{3-}, Cl^-) analysis were kept in an airtight plastic ice-cold cooler at 4 °C and transported to the wet laboratory of the Emmandy Laboratory and Consultancy Limited, Ibadan, South-west Nigeria for heavy metals analysis.

The cations and anions were determined using UV/VIS Spectrophotometer (Model- Jenway 6705) at a specified wavelength. Sediment samples were collected with 0.25 m^2 Van-Veen Grab sampler at each station, aboard the research boat. Samples were stored in aluminum foil and labelled for heavy metals (HM). Before analysis, sediment and fish samples were sun-dried for 4 days and then sieved through a 200 µm sieve mesh. The sieved samples were further disaggregated and homogenized in a porcelain mortar and pestle and re-sieved. Approximately 0.5 g were leached with 20 ml of aqua regia (a mixture of nitric acid and Hydrochloric acid) (Ibanga *et al*. (2019). The heavy metals (Pb, Cu, Ni, Cd, Co, Mn, Cr and Cu) concentrations were determined by Argillent 200A model Atomic Absorption Spectrophotometer (AAS).

RESULTS

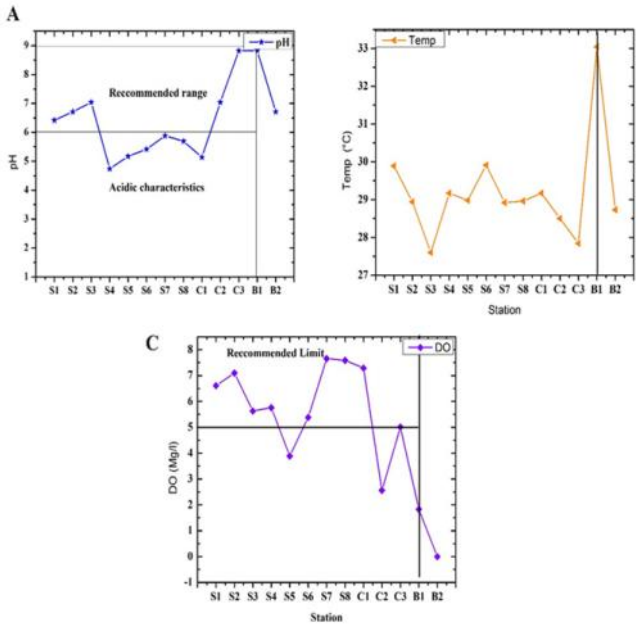

Figure 2. (a) PH, (b) Temperature(c)Dissolved Oxygen of Ayetoro Coastal waters

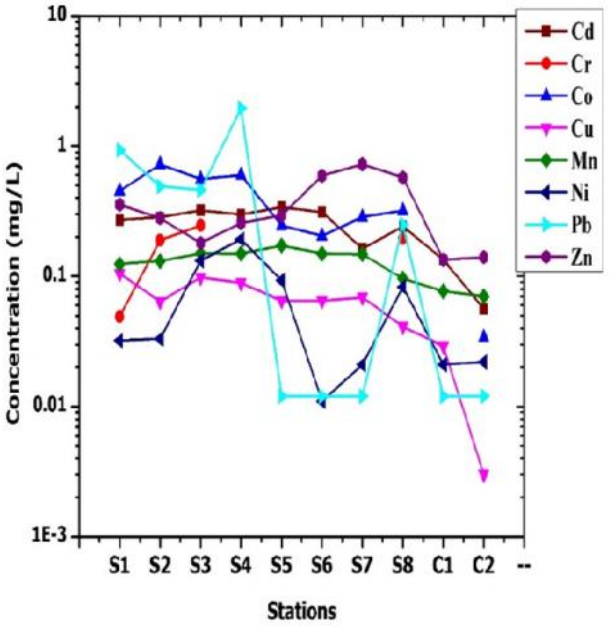

Fig. 3. Heavy metal Concentration in representative Fish sample

Table 1. Heavy metal concentrations in Aiyetoro coastal sediments (Mg/Kg)

S/N	Code	Pb	Mn	Cr	Cu
1.00	ST-1	2.40	52.95	204.50	77.40
2.00	ST-2	1.70	68.71	238.40	72.10
3.00	ST-3	2.10	63.34	293.10	218.00
4.00	ST-4	2.10	64.38	292.80	94.40
5.00	ST-5	1.40	98.72	226.30	104.40
6.00	ST-6	1.90	101.36	231.30	92.30
7.00	ST-7	1.30	80.17	71.40	139.10
8.00	ST-8	1.50	76.51	242.10	94.00
9.00	CTR1	1.40	30.72	90.40	42.20
10.00	CTR2	1.20	62.67	182.70	86.40
11.00	CTR3	1.50	22.92	185.00	108.10
Min		1.20	22.92	71.40	42.20
Max		2.40	101.36	293.10	218.00
Av		1.68	65.68	205.27	102.58

Table 2. Heavy metal concentrations in representative fish samples of Aiyetoro coastal water (Mg/Kg)

S/N	Cd	Cr	Co	Cu	Mn	Ni	Pb	Zn
F1	3.03	BDL	0.77	4.29	3.9	0.28	3.05	24.8
F2	1.71	BDL	0.25	1.96	2.2	0.27	ND	14.4
F3	2.33	BDL	BDL	2.75	2.67	0.23	ND	16.5
F4	2.13	BDL	2.04	2.29	3.05	0.17	2.31	17
F5	1.95	BDL	0.84	1.83	4.82	2.1	BDL	15.9
Min	1.71	BDL	0.25	1.83	2.2	0.17	2.31	14.4
Max	3.03	BDL	2.04	4.29	4.82	2.1	3.05	24.8
Av	2.23	BDL	0.975	2.624	3.328	0.61	2.68	17.72

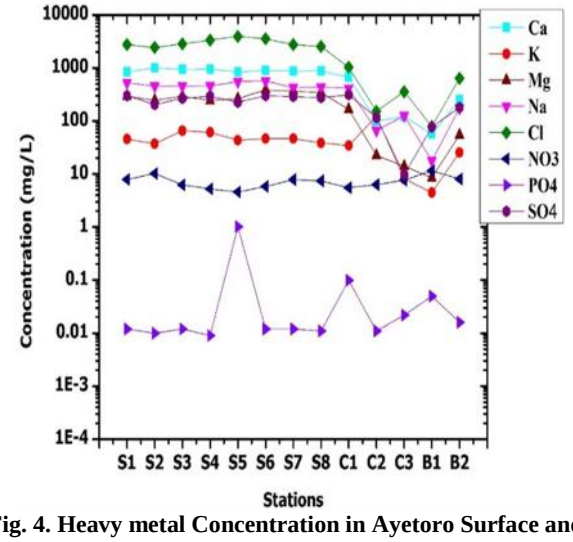

Fig. 4. Heavy metal Concentration in Ayetoro Surface and Groundwater

DISCUSSION

The concentration of heavy metals in water of the study area are shown in Fig D or, Appendices 1,2 &3). The results showed Mn (0.070-0.177mg/L), Cu (0.003-0.105 mg/L), Cd (0.163-0.322 mg/L), Pb (0.01-1.95 mg/L), Ni (0.02-0.09mg/L), Zn (0.13-0.73mg/L) Cr (0.005-0.246mg/L) and Co (<0.01-0.72mg/L). The permissible limit for metals in coastal waters are variable for Mn (5mg/L), Cu (<1mg/L), Cd (<1mg/L), Pb (<1mg/L). Ni (<1mg/L), Zn (<1mg/L), Cr (<1mg/L), and Co (<1mg/L) respectively (FEPA, 1991, FMNEV, 2001). All the metals (with the exception of Pb) falls within the aforementioned permissible limit for coastal waters in Nigeria. The high values of Pb (1.95mg/L) at station 4 is an indication of point source anthropogenic effluent of petroleum spills and combustion from vessels during transportation and downstream petroleum product transportation.

Sediments act as an ultimate sink of heavy metals from the particulate matter and surrounding environments (Ajani *et al*., 2017). The average grain/particle size analysis of sediment from the sampling stations are approximately sandy mud, 12%, silty mud 34% and clayey mud 54%. The combination of silty and clayey mud (86%) which are very fine soil texture (less than 63 microns) makes the sediments of the Mahin mud coast to be more prone to flooding relative to the beach sand in the Lagos coastal waters that are predominantly coarse to medium sandy texture (greater than 63 microns). The concentration of heavy metals in the sediment range from Cr, 71.40-293.10mg/kg; Cu, 42.20-218.00 mg/kg; Mn, 22.92-101.36 mg/kg Pb, and Pb, 1.20-1.68 mg/kg (Table 1). The trend of studied heavy metals in the Ayetoro coastal sediments were in the order of Cr >Cu >Mn > Pb. The higher Cr, Cu and Mn concentrations in Ayetoro coastal sediments further suggest point source effluent of petroleum spills and combustion from vessels during transportation and downstream petroleum product transportation. Cu, Pb, Cr and Cu have been reported as associated elements with petroleum spills and refining processes (Dara, 2001).

Heavy metal concentration in the gills and intestine of *Tilapia guineensis*and *Euthynnusalleteratus* species reveal variable Cd (1.71-3.03mg/Kg); Cr (below detection level, bdl); Co (bdl-2.04mg/Kg); Cu (1.83-4.28mg/Kg); Mn (2.20-4.82mg/Kg); Ni (0.17-2.10mg/Kg) and Pb (bdl-3.05mg/Kg) (Table 2). The higher concentration of the metals above the permissible limit highlighted in section 5 (permissible levels of heavy metals in coastal waters) indicated bioaccumulation of the heavy metals the fish gills an intestine. The main factors affecting bioaccumulation of heavy metals in fish are the exposure of the fish to the heavy metals from the water column. These higher values above the permissible limit is an indication of a serious threat of the aforementioned metals (Cu, Zn, Pb, Cd, Co and Ni) with the exception of Mn and Cr (that are below the permissible limit) to the marine lives of Ayetoro coastal waters.

Conclusion

The result of this study showed that Ayetoro community and marine life had been negatively impacted by the resultant seawater intrusion and anthropogenic effluents, hence, there is an urgent need for remediation in order to save the community from attendant health problems.

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