Chemistry Research Journal, 2017, 2(2):96-103

Available online www.chemrj.org

Research Article

ISSN: 2455-8990
CODEN(USA): CRJHA5

Impact of Anthropogenic Activities on Metal Load of Sagbama River, Niger Delta Region of Nigeria

Godwin A. Ebong*, Helen S. Etuk

Chemistry Department, University of Uyo, Uyo P. M. B. 1017, Uyo, Akwa Ibom State, Nigeria

Abstract Impact of anthropogenic activities on metal load of Sagbama River was investigated. Water samples were obtained at four (4) designated locations namely: Sagbama, Patani, Odi and Toru-Orua along Sagbama River in Bayelsa State, Nigeria. Standard procedures were employed for the collection and treatment of water samples. Samples collected were analysed using spectrophotometric methods for their copper, lead, iron, nickel, cadmium and zinc content. The following mean concentrations (mg/l) were recorded for the metals: (1.03±0.14) Cu; (0.04±0.01) Pb; (0.32±0.03) Fe; (0.03±0.01) Ni; (0.03±0.01) Cd and (3.27±0.23) Zn. The mean results of all the metals were higher than their recommended limits for drinking in Nigeria. Water quality assessment (WQA) revealed that, level of trace metals obtained rendered untreated water from Sagbama River unsuitable for human consumption. It also disclosed that all the locations studied were seriously and negatively impacted by activities within and around these areas. The general results indicated that, human activities in the studied area have impacted negatively on the quality of sagbama River regarding its metal contents. The environmental and health implications of metal status of Sagbama River have been enumerated.

Keywords Anthropogenic activities, Niger Delta, Sagbama River, Trace metals, Water Quality Index

1. Introduction

Bayelsa State is dominated by water systems including surface and groundwater, lakes, freshwater, brackish and marine ecosystems [1]. FGN [2] reported that, majority of people in the rural areas including the studied area depend on surface water and rainfall for their drinking and domestic purposes. The major occupation of the people in Bayelsa State is fishing and a greater proportion of people in the area depend on fish for their animal protein. Thus, any mechanism that may hinder or eradicate these benefits from people of the area will result in social, economic and health problems. However, the quality of water available in the area may not be suitable for drinking and other domestic purposes as their natural quality may have been altered by activities of oil and oil related companies operating in the area. Water is a necessity for life but there are potential health implications associated with the consumption of contaminated/polluted water [3]. Reports have also indicated that, the quality of water available for people in a community has great influence on the health status and quality of such a community [4-5]. Study by Nwidu *et al.* [5] revealed that, consumption of contaminated aquatic organisms and water in Bayelsa State may have resulted in the prevalence of water borne diseases in the area. Investigations have shown that most deaths recorded in the world especially in developing countries are attributed to water borne diseases [6–8]. It has also been reported that, anthropogenic activities may have resulted in the extinction of some species of aquatic organisms including fish or lack of fish is such aquatic ecosystem [9–14]. All metals are potentially harmful to most living things including

human at some levels of exposure and absorption [15]. The accumulation of metals in aquatic organisms may affect not only the productivity of such organisms but may eventually affect the health of human beings that depend on these aquatic organisms as a major source of protein [16]. Hence, the provision of potable and sufficient quantities of water for citizenry in the world especially in developing countries has been one the major problems of the 21st century [17]. Since the discovery of oil in Oloibiri Bayelsa State in 1956, the region has experienced serious environmental degradation by the activities of oil companies and downstream industries within the area. The devastating state of the area led to the initiation of processes for the cleanup of Ogoni land recently by Nigerian Government as directed by UNEP. Several studies conducted to assess the quality of surface water in Niger Delta region of Nigeria confirmed the non-potability of water bodies in the area [4, 18–26]. However, literature has shown that the quality of water from Sagbama River in Bayelsa State is yet to be assessed in order to establish it suitability or otherwise for human consumption. Hence, this study was conducted to evaluate and establish the potability or otherwise of untreated water from Sagbama River for drinking and other domestic purposes. This study also aimed at exposing the impact of the studied river on aquatic organisms and by extension the health implications associated with consumption of water/aquatic organisms from the studied river.

2. Materials and Methods

2.1. Study Area

Bayelsa is a state in the south-south region of Nigeria and lies between Delta and Rivers, with its capital in Yenagoa. Bayelsa State has one of the largest crude oil and natural gas deposits in Nigeria and host major oil companies such as Shell, Agip and ChevronTexaco. Thus, the activities of these oil companies have seriously impacted in the area. Crude oil was first discovered and harnessed in Oloibiri, Ogbia local government area of Bayelsa State in 1956. Since then the state has witnessed intensive oil exploration and exploitation activities which have may have impacted negatively on the host communities. Bayelsa State locates geographically within Latitude 04° 15! North, 05° 23! South and longitude 05° 22! West and 06° 45! East.

It shares boundaries with Delta State on the North, Rivers State on the East and the Atlantic Ocean on the West and South. Sagbama is a local government area in Bayelsa State which has been impacted negatively by the activities of oil and oil related companies. Sagbama lies within latitude 5° 10! North and longitude 6° 12! East. The presence of oil in the state has increased the population, industrial and commercial activities in Sagbama local thereby resulting in elevated waste materials in the area. Consequently, these waste materials have impacted negatively on the host environment.

2.2. Analytical Methods

Water samples were obtained according to the standard procedures by APHA [27]. This study was conducted in the month of November, 2008 by collecting water from four (4) randomly chosen points at each designated location along Sagbama River and composited them to form a composite sample for that location. Water samples were collected in plastic container pre-treated with 0.1 M HCl acid and sun-dried. The plastic container was first rinsed with the water to be sampled before collection. Samples collected were treated with 1 ml of concentrated HNO_3 to fix the metals to be analysed. These samples were further treated and analysed for their copper, lead, iron, nickel, cadmium and zinc levels using Unicam 929 AAS following standard procedures by APHA [27] and Radajevic and Bashkin [28]. Pollution index (PI) of trace metals was determined using the equation:

$$PI = \frac{\text{Concentration of Metal Q}}{\text{Standard for Metal Q}} \text{ ---------- (1)}$$

According to the methods of Tamasi and Cini [29] metal index (MI) of trace metal was evaluated using the formula:

$$\text{Metal index (MI)} = \sum_{i=0}^{n} Ci/(MAC)i \text{ ---------- (2)}$$

Where Ci is the concentration of each element; MAC is the maximum allowable concentration.

3. Results and Discussion

Results for mean concentration of trace metals in Sagbama River are shown in Table 1. Tables 2 and 3 indicate pollution index (PI) and metal index (MI) of trace metals respectively in studied locations along Sagbama River.

3.1 Distribution of Trace Metals along Sagbama River

Table 1: Concentration (mg/l), mean, standard deviation and range of trace metals in Sagbama River compared NIS[30] drinking standard.

	Copper	Lead	Iron	Nickel	Cadmium	Zinc
Sagbama	0.90	0.02	0.28	0.03	0.02	3.05
Patani	0.92	0.04	0.31	0.02	0.03	3.11
Odi	1.13	0.04	0.33	0.03	0.03	3.37
Toru-Orua	1.17	0.05	0.36	0.03	0.04	3.54
Mean	1.03	0.04	0.32	0.03	0.03	3.27
SD	0.14	0.01	0.03	0.01	0.01	0.23
Range	0.27	0.03	0.08	0.01	0.02	0.49
NIS limit	1.00	0.01	0.30	0.02	0.003	3.00

Copper is required for proper growth by flora and fauna in both terrestrial and aquatic environments, it is also involved in normal human metabolic activities [31-32]. However, at high concentrations copper can affect life negatively in both aquatic and terrestrial ecosystems including human [33–34]. A mean concentration of 1.03±0.14mg/l was recorded for copper in Sagbama River and is higher than that reported in the region by Wangboje and Ikhuabe [26]. The high copper concentrations in Sagbama River may be attributed to the intensive industrial activities in the area by oil and oil related companies. The obtained mean is also higher than the Nigerian standard for copper in drinking water (1.00 mg/l) by NIS [30]. Hence, consumption of water from Sagbama River may cause nausea, vomiting, liver and kidney problems in human and result in a significant reduction in population of fish in the studies aquatic ecosystem [31, 35-36].

Lead is an uncommon element but highly toxic even at low concentrations, a mean concentration of 0.04±0.01mg/l recorded is higher than that reported in the area by Omoigberale *et al*. [25]. This may be attributed to negative impact of oil activities in the studied area [37-38]. The mean obtained is as well higher than 0.01 mg/l stipulated for drinking water in Nigeria by NIS [30]. Consequently, drinking of untreated water from Sagbama River may expose the consumers to depression, nausea, abdominal pain, loss of coordination, vomiting, diarrhea, anemia and other health implications [39- 0].

Iron is vital for all life on earth and abundant in the earth's crust but due to its low solubility the concentration in aquatic environment is naturally low [22, 41]. Notwithstanding the essential nature of iron at high concentrations it may result in negative effects to life in aquatic and terrestrial environments including human. A mean of 0.32±0.03 mg/l was recorded for iron in Sagbama River which is lower than that obtained in Niger Delta by Enuneku *et al.* [21]. However, the mean obtained is higher than 0.30 mg/l recommended for drinking water in Nigeria by NIS [30]. Thus, consumption of untreated water from the studied River may cause iron toxicity and its attendant's effects on the consumers [42-43]. This high iron concentration in Sagbama River may also affect physiology and ecology of aquatic plants, damage gill tissues and cause anemia in fish within the aquatic ecosystem studied [44-45].

The essentiality and toxicity of nickel for human, plants and animals has been reported [46-47]. However, at concentration a little higher than what is required for proper functioning of living cells it can be highly poisonous [48]. This study recorded a mean nickel concentration of 0.03±0.01 mg/l which is lower than that reported by Amadi [19] in a River within the studied Niger Delta region of Nigeria. The mean obtained is also above the permissible limit of 2.00 mg/l for drinking water in Nigeria by NIS [30]. Hence, the high nickel concentration in Sagbama River may lead to nickel toxicity and its associated health implications on the consumers of untreated water from the river as reported by USEPA [48] and Chang [49]. It can also cause behavioural changes such as surfacing, rapid mouth

and opercular movements, convulsions and eventually death of fish [50-51]. The high nickel content in the studied river may be accredited to the area associated with crude oil deposit [52-53].

Cadmium is a known toxic element even at a low concentration and can interfere with the necessary functions of the essential elements in living cells [54]. This study recorded a mean of 0.03±0.01 mg/l for cadmium which is higher than that reported in the zone by Omoigberale *et al*. [25]. This is also above the recommended limit for drinking water in Nigeria (0.003 mg/l) by NIS [30]. The negative impact of industrial activities in the studied area may result in the high cadmium level in Sagbama River reported. Accordingly, consumption of untreated water from the studied river may result in intestinal, liver, kidney and other associated problems in the consumers [55-56]. It can as well have negative effect on growth rate and embryonic development of aquatic organisms [57].

Zinc is required for normal growth of plants and animals; in human it is vital for enzymatic and reproductive activities [58]. Nevertheless, high concentration of zinc in human can cause negative health implications. A mean concentration of 3.27±0.23 mg/l for zinc in Sagbama River and this is consistent with that obtained by Amadi [19] but higher than that reported in the region by Ideriah *et al*. [23]. The mean zinc concentration is also higher than 3.00 mg/l stipulated for drinking water in Nigeria by NIS [30]. The high zinc concentration reported in Sagbama River may be attributed to the impact of industrial and activities in the area by oil and associated downstream companies. This may result in nausea, vomiting, dizziness, colics, fatigue, fever and diarrhoea in the consumers of untreated water from the river [59]. It may also have negative impact on the aquatic organisms and along the food chain as reported by Forth *et al*. [60] and Robinette [61].

3.2. Water Quality Assessment (WQA)

Two different quality indices were employed to determine the metal contamination of Sagbama River in Bayelsa State, Nigeria namely:

(1) Pollution index (PI) which is based on individual element calculations was used for the evaluation of water quality in Sagbama River as reported by Akpoveta *et al*. [62].

(2) Metal index (MI) is based on a total trend evaluation of the present status of the studied river was also used for assessing the water quality. The higher the concentration of a metal compared to its respective MAC value, the worse the quality of the water. MI value > 1 is a threshold of warning [63].

Table 2: Pollution Index of trace metals in Sagbama River, Bayelsa State

	Copper	Lead	Iron	Nickel	Cadmium	Zinc
Sagbama	0.90	2.00	0.93	1.50	6.67	1.02
Patani	0.92	4.00	1.03	1.00	10.00	1.04
Odi	1.13	4.00	1.10	1.50	10.00	1.12
Toru-Orua	1.17	5.00	1.07	1.50	13.33	1.18
Mean	1.03	3.75	1.03	1.38	10.00	1.09

The relative pollution prospect (pollution index) of studied trace metals in Sagbama River is shown in Table 2. Mean pollution indices of all the studied trace metals were higher than 1.00 indicating significant degree of pollution by these trace metals especially Cd and Pb with Pi values of 10.00 and 3.75 respectively. According to Akpoveta *et al.* [62] pollution index of a parameter above 1.00 indicates substantial degree of pollution by such parameter in environment investigated. However, pollution indices of copper at Sagbama and Patani with values of 0.90 and 0.92 respectively indicate non-polluting nature of copper at these two locations. Pollution index analysis also revealed the non-polluting nature of iron at Sagbama with Pi value of 0.93. This finding is consistent with the existence of these metals within their recommended limits at these locations.

Table 3: Metal Index (MI) of trace metals in Sagbama River, Bayelsa State

	Copper	Lead	Iron	Nickel	Cadmium	Zinc	Sum	Remark
Sagbama	0.90	2.00	0.93	1.50	6.67	1.02	13.02	TOW
Patani	0.92	4.00	1.03	1.00	10.00	1.04	17.99	TOW
Odi	1.13	4.00	1.10	1.50	10.00	1.12	18.85	TOW
Toru-Orua	1.17	5.00	1.20	1.50	13.33	1.18	23.38	TOW

TOW =Threshold of warning

Metal index indicates the trend assessment of the present status by calculating all studied metals. Results of metal index obtained revealed that, all the designated locations along Sagbama River were seriously polluted by these metals thus not suitable for drinking and domestic use unless properly treated. The MI values varied between 13.02 and 23. 38 obtained at Sagbama and Toru-Orua respectively. Consequently, the activities by oil and associated downstream industries in the studied region may have introduced substantial amounts of these trace metals into the host environment. The MI values of trace metals at all the studied locations were higher than 1, indicating threshold of warning for the residence of the studied area on the impending disaster and water quality of Sagbama River [63].

4. Conclusion

The anthropogenic influence on trace metal load of Sagbama River has been assessed and results obtained confirmed that industrial activities within the area may have contributed significant amount of these metals to the host environment. The mean concentrations of all the metals determined in Sagbama River were above the Nigerian standard for drinking water. Thus, the prolong consumption of this untreated water which is highly polluted with toxic metals may have resulted in the prevalence of some health problems associated with metal toxicity in the area. The pollution and metal indices of trace metals in studied river corroborated the highly contaminated nature of all the designated located along Sagbama River by trace metals. Hence, water from Sagbama River should be properly treated to eliminate these toxic metals before consumption to avoid health problems associated with their toxicities. The anthropogenic sources of these metals which may likely include activities by oil companies should be monitored and controlled to forestall a devastating situation in the region. Gas flaring and discharge of untreated waste materials into the host environment by companies operating in the area should be discouraged.

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