



Heavy metals in surface water and sediment of mini-ndai creek, Rumuolumeni, Rivers state, Nigeria

Owoh-Etete Ukamaka^{1*}, Ogunbiyi Oluwagbenga J², Eucharia Ngozi O², Michael Nancy E²

¹Department of Biology, Faculty of Natural and Applied Sciences, Ignatius Ajuru University of Education, Port Harcourt, Nigeria

²Biology Unit, Faculty of Science, Air Force Institute of Technology, Kaduna, Nigeria

Abstract

The study examined five heavy metals: zinc (Zn), chromium (Cr), iron (Fe), lead (Pb) and cadmium (Cd) levels on the sub sediment and surface water in tidal creek of Mini-Ndai. Four stations were employed (station 1 – station 4) using station 4 as control station. Samples were analyzed using Atomic Absorption Spectrophotometer (AAS) while the results were presented using mean \pm SD. The result revealed the presence of the following heavy metals in surface water: Cd, 0.004-0.010 mg/l; Fe, 0.4-1.75 mg/l; Zn, 0.57-2.01 mg/l; Cr, 0.25-1.13 mg/l and Pb 0.45-1.51 mg/l while the following were obtained in sediment: Cd, 0.27-0.82 mg/kg; Fe, 112.47-972.7 mg/kg; Zn, 6.58-28.76 mg/kg; Cr, 1.10-6.53 mg/kg and Pb, 0.52-1.73 mg/kg. The mean concentration of metals in water were either above or within the permissible limits of World Health Organization (WHO) and Standard Organization of Nigeria (SON) for drinking water while that of sediment generally exceeded WHO and Federal Environmental Protection Agency (FEPA) regulatory limits. In conclusion, the levels of heavy metals in sediment were higher than those in surface water. Thus, the values in the control station were lower than those obtained from other stations (station 1 – station 3). This study therefore advocates environmental surveillance of this creek in order to obtain good sediment quality.

Keywords: heavy metal, river, surface water, sediment, creek

Introduction

Water is a veritable tool of natural origin which serves for useful purposes to man. The earth's surface is made up of 70% water, which includes rivers, lakes, streams, sea, ocean and ground waters. All these forms of water are very important in life cycle (Arimieari *et al.*, 2014) ^[3]. All living organism on the earth need water for their survival and growth (Behera *et al.*, 2014). It is important for agriculture, industry and human existence. The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem.

Natural water contains different types of impurities which are introduced into the aquatic system by different ways such as weathering of rocks and leaching of soils, dissolution of aerosol particles from the atmosphere and from several human activities including mining, processing and the use of metal based materials (Behera *et al.*, 2014) ^[6]. Heavy metals are among the most common environmental pollutants and their occurrence in rivers and biota indicate the presence of natural or anthropogenic source (Mohiuddin *et al.*, 2001) ^[13].

Cadmium has been described as one of the most dangerous trace elements in food and in the environment, not only for its high toxicity but for its high persistence in the environment (Battaglia *et al.*, 2005) ^[5]. Chromium is another toxic metal that its source of contamination in the surface water is from various anthropogenic activities which include municipal effluents, laundry chemicals, paints, leather, road run off due to tire wear, erosion of washing among others. The abnormal state of chromium in waste water effluent shows contamination from the textile and tanneries (Pachpande and Ingle, 2004) ^[16] and when these effluents enter into the river, it contaminates both the surface water and sediment of the river. Although, other heavy metals such as zinc (Zn) and iron (Fe) are essentially required for supporting biological processes, their environmental concentration once beyond the acceptable limit constitutes serious toxicological problems (Perez-Lopez *et al.*, 2006) ^[17].

In recent times, the activities of oil bunkering and the practice of dumping domestic wastes by the river creek side has further worsened the contamination load of nearby surface water bodies in the Niger Delta.

Several studies have shown that the sediment is usually highly toxic than the water component of aquatic environment (Babatunde *et al.*, 2012; Amah *et al.*, 2012; Tove *et al.*, 2010) ^[4, 2]. The ultimate discharged of effluents by industries and other anthropogenic activities in and around creeks and rivers constitute a major environmental challenge particularly in developing areas such as the Niger Delta in Nigeria (Moslen and Daka, 2016) ^[14]. It has been ascertained that human-related inputs are generally more significant than natural sources in their biogeochemical cycles. However, the aim of this study is to evaluate levels of some heavy metals in surface

water and sediment of Mini-Ndai Creek, Rumuolumeni, Rivers State, Nigeria. It is hoped that results of this study will serve as baseline environmental data for monitoring of heavy metals accumulation in aquatic system.

Materials and methods

Study Area: The study area Mini-Ndai creek (Fig. 1) is located in Rumuolumeni in Obio/Akpor Local Government Area of Rivers State. The Mini-Ndai creek lies between longitude $4^{\circ} 48' 25''$ N and latitude $6^{\circ} 55' 51''$ E. It is tidal in nature. The climate condition is tropical with two distinct seasons (wet and dry season). The vegetation is dominated by mangroves (*Avicennia nitida* and *Rhizophora* spp) and the biota found includes blue crab (*Callinectes amnicola*), periwinkle (*Tympanotonus fuscatus*), mudskipper, etc. Anthropogenic activities such as oil bunkering, abattoir operations and discharged of waste water runoff from domestic and municipal are some of the daily routine of the people living in this community. The Mini-Ndai creek thus, provides a source of water for domestic use, serves as a means of transportation for human and timber products and provides recreational area for swimming and fishing for the host community.

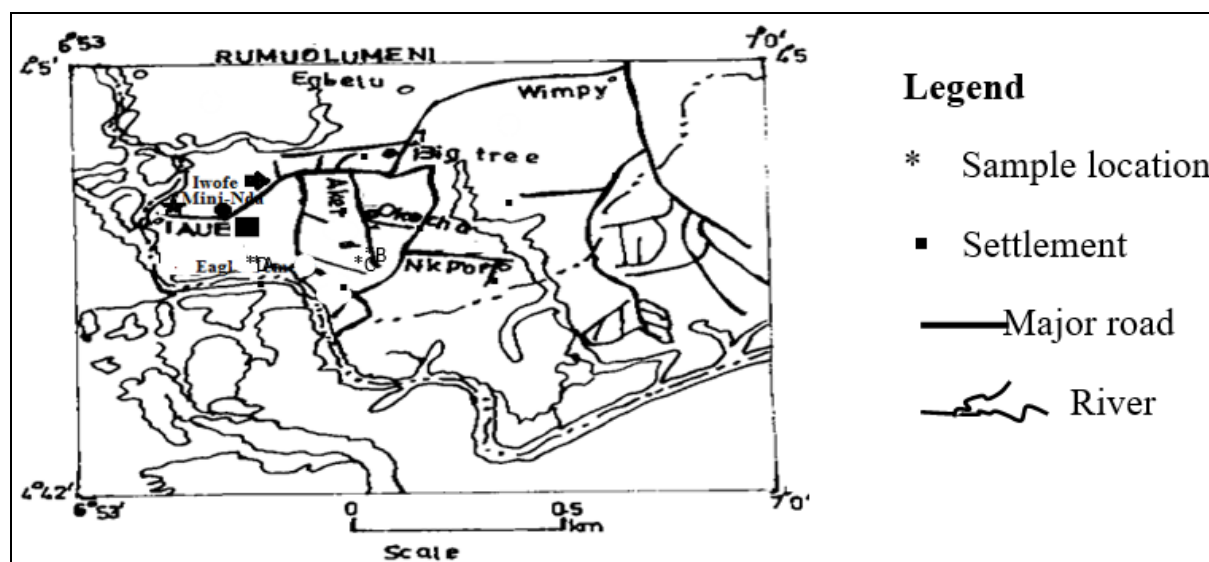


Fig 1: Location of sampled stations in the study area

Sample collection

Glass cup was used for water samples collection at different stations on the creek (Mini-Ndai) and were transferred into a 1.5 litres glass bottles to make a composite sample. Concentrated hydrochloric acid was added to the samples to prevent microbial activities. The glass bottles were corked tightly labeled and transferred into cooler containing ice chests. They were treated and analyzed for heavy metals using appropriate methods. Eckman grab sampler was used to collect sediment samples at the same stations where water samples were collected and were transferred into a 1.5 litres glass container. The containers were corked properly labeled and placed in a cooler containing ice chest for onward transportation to the laboratory for the determination of heavy metal.

Sample Analysis

Samples were analyzed using standard methods involving in the operation of AAS.

Statistical Analysis

Statistical analysis was done using One-Way ANOVA obtained from SPSS 16.0. Significant values were set at $p < 0.05$ while the results were presented as mean \pm SD.

Results

The results of some level of heavy metals in surface water and sediment from Mini-Ndai Creek at the different sampling stations were summarized in Table 1 and 2.

Table 1: Heavy metal concentration (in mg/l) in surface water from Mini-Ndai Creek

Sampling stations	Cd	Fe	Zn	Cr	Pb
1	0.0143	2.509	3.416	1.678	2.349
2	0.011	2.367	2.794	1.378	2.042
3	0.015	1.891	1.116	1.141	1.637
4	0.000	0.239	0.694	0.313	0.004
MEAN	0.010	1.752	2.005	1.128	1.508

S.D	0.004	0.45	0.57	0.25	0.45
WHO (2011)	0.003	2.0	3.0	0.05	0.01
SON (2007)	0.003	2.0	3.0	0.05	0.01

Table 2: Heavy metal concentration (in mg/kg) in sediment from Mini-Ndai Creek

Sampling stations	Cd	Fe	Zn	Cr	Pb
1	0.473	1.286.361	43.872	7.850	2.914
2	0.290	1.067.532	35.489	9.118	1.877
3	0.214	869.489	27.369	5.842	2.069
4	0.087	667.328	8.321	3.321	0.0743
MEAN	0.266	972.678	28.763	6.532	1.734
S.D	0.082	112.47	6.58	1.10	0.52
FEPA (1991)	0.05 – 0.2	1.5	1.0		0.05

There are remarkable variations in the heavy metal concentration in sediment and surface water at Mini-Ndai Creek particularly in station 1, which was traced to bunkering activities around the area. The level of heavy metals in the surface water was low when compared with that of sediment. Cadmium (Cd) values in surface water were <0.1 mg/l across stations with a mean value of 0.010 ± 0.004 mg/l was observed within the stations. The highest zinc (Zn) value was 3.416 mg/l in station 1 while the lowest value of zinc was 0.694 mg/l at station 4 (control). Chromium (Cr) recorded spatial variation in the study stations, as station 1 had 1.678 mg/l, station 2 had 1.378 mg/l and station 3 had 1.141 mg/l whereas the control, station 4 had 0.313 mg/l. The highest lead (Pb) concentration was 2.349 mg/l while the lowest was 0.004 mg/l.

In the sediments, the concentration of Cr was highest in station 2 (9.118 mg/kg) and lowest in station 4 (3.321 mg/kg). Cd concentrations ranged from 0.087 mg/kg to 0.473 mg/kg with highest values recorded in station 1 (point source). The concentration of Zn and Fe were also higher in station 1 compare to other stations. This portends the influence of anthropogenic factors in the distribution of heavy metals within the study area. The highest concentration of Pb was 2.914 mg/kg at station 1, while the least concentration was 0.0743 mg/kg.

Discussion

Generally, the concentrations of the metals in the sediments were higher than those of the surface water. All the concentrations of the metals in the sediment differ significantly ($p < 0.05$) from those of the surface water. The resultant effect of this is that sediment may cause surface water to contaminate with heavy metals such as Cd, Pb, Fe or Zn long after the source of pollutant has ceased. Furthermore, higher levels of Cd in the sediment were observed in station 1, 2, and 3 than those of station 4 (control station) as a result of various activities carried out within the stations.

However, Cd mean value of surface water (0.010 ± 0.004 mg/l) obtained in this study are lower than those obtained by Emmanuel *et al.* (2017)^[9] from Kolo Creek and Dambo (2000)^[7] from Lower Bonny Estuary. Also the mean level of Cd in the sediment of this study was 0.266 ± 0.082 mg/kg which was higher when compared with those reported in similar studies by Agbozu and Ekweozor (2004)^[1], Dambo (2000)^[7] and Emmanuel *et al.* (2017)^[9]. The high level of Cd obtained in the sediment of the study area indicates the contamination of aquatic resources which the local populace depends on as a means of livelihood.

The highest value of 1.628 mg/l was observed for Cr in surface water of station 1. In Station 2, higher value of 9.118 mg/kg of Cr was also observed in sediment (see Table 1 and 2). However, the reasons for such a high level of Cr in sediment of station 2 could be attributable to abandoned metal drums and cans dumped on the Creek. This observed value of Cr in the surface water was higher than that of WHO (2011)^[21] standard of Cr (0.05 mg/l) for aquatic life water quality. However, the high mean value of Cr in surface water obtained in this study (1.128 ± 0.25 mg/l) could be as a result of various occupational activities which have negative impact on the river.

Of all the metals, Fe has the highest value both in the surface water (2.509 mg/l) and in the sediment (1.286.361 mg/kg) for station 1 of the study area. Those values from station 1 were significantly ($p < 0.05$) different from the other stations (see Table 1 and 2). The higher value obtained for Fe level in station 1 could be as a result of illegal oil bunkering activities carried out in station 1 before the commencement of the study.

Furthermore, Fe concentrations in both surface water and sediment in this study was higher than the concentrations reported for surface water and sediment from Niger Delta region. For instance, Emmanuel *et al.* (2017)^[9] reported concentration of Fe in the surface water and sediment from Kolo Creek in the range of 0.137 ± 0.012 mg/l - 0.157 ± 0.0129 mg/l and 3.600 ± 0.035 mg/kg - 3.810 ± 0.021 mg/kg respectively. Udoh and Akpan (2010)^[20] reported the concentrations of Fe in surface water and sediment from Okrika River to be in the range of 2.5 - 3.8 mg/l and 8.3 - 54.3 mg/kg respectively.

The levels of Zn in the sediment samples were generally high and were found to be higher than the limit recorded by FEPA for sediment. This implies that the leaching and deposition of heavy metals in the sediment was typically the same at the various locations. It is also necessary to note that Zn is a trace element that is

necessary for the growth of aquatic animal and its concentration has effects on plankton communities (Masoud *et al.*, 2005) ^[12]. Zinc may also increase the acidity of waters. Water soluble Zn that is located in soil can contaminate ground water. Plants often have a Zn uptake that their system cannot handle, due to the accumulation of Zn in soils (Greany, 2005) ^[11]. Furthermore, Zn can interrupt the activity of certain organisms in soil, as it can negatively influences the activity of micro-organisms and earthworms in the soil, thus retarding the breakdown of its organic matter (Greany, 2005) ^[11].

The mean concentrations of Pb for both the surface water (1.508 ± 0.45 mg/l) and sediment (1.734 ± 0.52 mg/kg) of Mini-Nda Creek exceeded the data recorded by WHO for surface water (0.01 mg/l) and FEPA for sediment (0.05 mg/kg). These values were higher than those obtained from the Okirika River in the Niger Delta by Udoh and Akpan (2010) ^[20], Kolo Creek by Emmanuel *et al.* (2017) ^[9] and Etelebou Oil field by Ekweozor and Agbozu (2001) ^[8] but were lower when compared with the levels of Pb in the Sediments of Ukpoba River in Benin (Obashan and Oronsaye, 2000). This high level of Pb in both samples could be attributed to oil spills due to bunkering activities in the area which may likely pose threat to aquatic life within the ecosystem.

Conclusion

In conclusion, sediment showed higher concentrations of heavy metals in all the sampling station except that of control. Heavy metals examined also showed values above FEPA and WHO limits. This was attributed to human activities and natural effects in the study area. However, measures should be put in place by various governmental agencies and industries to check possible accumulation of the heavy metals in the aquatic biota. This is to prevent the local populace from the threat that may result from bioaccumulation of these heavy metals in the environment. The findings from this investigation can serve as baseline environmental data for monitoring of heavy metals accumulation in aquatic system.

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Competing interests

The authors declare that they have no competing interests.

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