Scientia Africana, Vol. 17 (No. 1), June 2018. Pp 22-28
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APPLICATION OF MULTIPLE SEDIMENT QUALITY GUIDELINES IN THE ASSESSMENT OF ORON CHANNEL SEDIMENT

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Received: 09-10-17
Accepted:06-05-18

ABSTRACT

The concentration of heavy metals in fresh water sediments from Oron Channel was investigated over a 2-year period (2015 to 2016). The concentration of Chromium (Cr), Copper (Cu), Iron (Fe), Nickel (Ni), Lead (Pb) Mercury (Hg), Cadmium (Cd) and Zinc (Zn) was determined by Atomic Absorption Spectrophotometer (AAS). The trace metals concentrations ranged over the following values: Cr: 4.90 – 5.36mg/kg; Cu: 0.17 – 0.22mg/kg; Fe: 103.94 – 109.65mg/kg; Ni: 1.03 – 1.11mg/kg; Pb: 0.02 -0.02mg/kg; Zn: 12.02 – 12.67 for the first year (2015) and Cr: 6.09 – 7.16mg/kg; Cu: 0.129 -0.33mg/kg; Fe: 196.23 – 199.02mg/kg; Ni: 156.26 – 158.63mg/kg; Pb: 0.02 – 0.045mg/kg; Zn: 13.04 – 13.52mg/kg for the second year (2016) while the concentrations of Hg and Cd were undetected at a detection limit of 0.001mg/kg in both years. The mean metal concentration in the period was in the order: Fe > Zn > Cr > Ni > Cu > Pb and Fe > Ni > Zn > Cr > Cu > Pb respectively. The mean metal concentration of all detected metals increased between the first and second year with a 7.5% increase in Zn and a 14576.64% in Ni. The sediment was assessed with respect to heavy metal content using the USEPA sediment quality guideline and the Consensus-Based sediment quality guideline (CBSQG).

Key words: Sediment, Heavy metals, Oron channel, Pollution

INTRODUCTION

The levels of trace metals in marine and fresh water sediments is a major concern because of the role sediment quality plays in the health of organisms that make up the aquatic ecosystem [1]. The health of the aquatic ecosystem is inextricably linked to that of other terrestrial and arboreal wildlife as well as humans through complex food webs [2]. With population increase, industrialization and all its trappings comes the proliferation of anthropogenic toxic trace heavy metal pollutants [3]. Heavy metals are a wide-variety of non-biodegrable elemental substances that are bioaccumulative in nature [4]. Trace heavy metals, though necessary for physiological activity (with the exception of Pb, Hg, Cd), are otherwise potent toxins, neurotoxins, teratogens, mutagens and carcinogens [5,6]. Sediments serve as sink and source for environmental contaminants such as heavy metals. Therefore heavy metal pollution of sediments is a serious threat to the well-being and survival of benthic species [7]. Heavy metals are bound to the finer particles in sediments [8]. The faunal and epibenthic organisms as well as other

aquatic organisms are exposed to heavy metals in sediments by contact with the sediments or ingestion of sediments particles. The actual bioavailability of heavy metals to these benthic dwellers are determined by a wide range of physico-chemical and biological factors, such as the chemical, the chemical speciation, physiology and behavior of the organism [9]. For higher trophic organisms, exposure is mainly through ingestion of contaminated food [9].

The assessment of heavy metals levels in the sediments of Oron channel based on established sediment quality guidelines is vital as it will help protect and inform to the quality and health of the benthic organisms and the ecosystem by extension.

MATERIALS AND METHODS

Oron channel located in Oron-city of Akwa-ibom state southern Nigeria, is a notable town that hosts numerous national institutions like the Nigeria maritime academy. Its geographical coordinates are as follows; latitude 4.51N and longitude 8.23E approximately. It is bound by the Bight if Bonny on southern axis, see figure 1.The river channel is a major fishing point in the area. Farmers are also main inhabitants of the city because of its fertile soil. Sampling points were located along the channel close to Osung and Washa areas.

For the river sediment collection, grab bottom sediment were collected periodically and randomly during the period (2015-2016). Collected samples were stored in plastic containers that have been rinsed previously with dilute HNO_3 acid and further washed with distilled water. The sediment samples were taken to the laboratory for heavy metal analysis.

The sediment samples were oven-heated at 105^0 C to remove residual moisture content, ground to powder and sieved. 5 grams of the sieved sediments were digested in 100ml solution of concentrated HNO_3 and HCl (1:1). The mixtures were agitated for about fifteen minutes and filtered through Whitman filter paper No. 42. Triplicate analyses of each sediment samples were done and the annual mean noted. The concentrations of each trace metal were thereafter determined at their respective resonance lines using AAS (AGILENT 55B MODEL).

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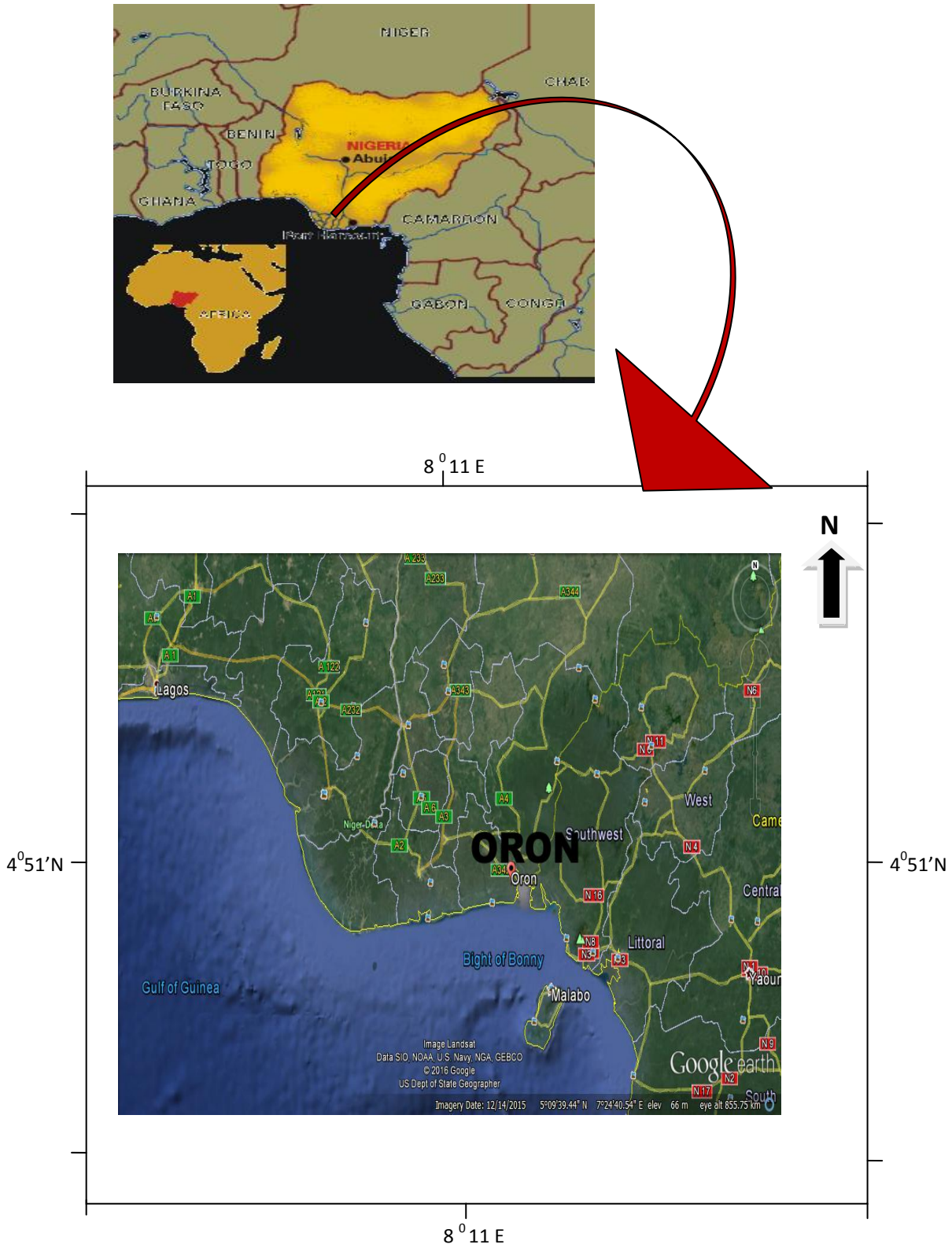

Fig. 1 Map showing ORON, the sampling point in Niger Delta (Google Earth, 2016)

RESULTS

Table 1: Range and mean heavy metal concentration for years 2015 and 2016

Trace metals	Trace metal mean- total concentration (mg/kg),2015	Range (mg/kg) (2015)	Trace metal mean-total concentration (mg/kg), 2016	Range(mg/kg) (2016)
Cr	5.11	4.90 -5.36	6.32	6.09 -7.16
Cu	0.19	0.17 -0.22	0.28	0.219-0.33
Fe	105.01	103.94-109.65	198.43	196.23-199.02
Ni	1.07	1.03 -1.11	157.04	156.26-158.63
Pb	0.02	0.02	0.034	0.02-0.045
Hg	bdl		bdl	
Cd	bdl		bdl	
Zn	12.4	12.02-12.67	13.33	13.04-13.52

Bdl= Below detection limit = 0.001mg/kg

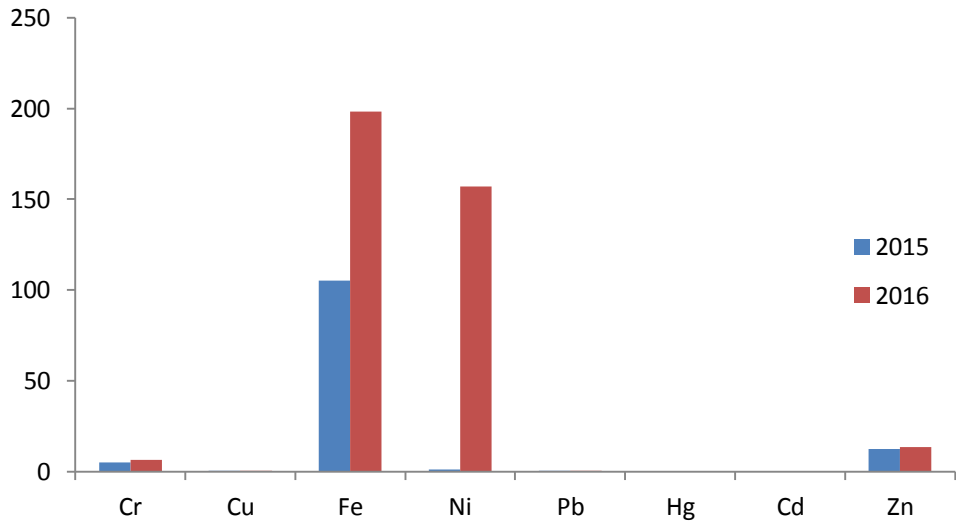

Figure 2: Mean metal concentration for 2015 & 2016

Table 2: Percentage increase in mean metal concentration between 2015 & 2016

	Mean Concentration		
Trace Metal	2015	2016	Percentage Increase (%)
Cr	5.11	6.32	23.68
Cu	0.19	0.28	47.37
Fe	105.01	198.43	88.96
Ni	1.07	157.04	14,576.64
Pb	0.02	0.034	70
Hg	bdl	bdl	-
Cd	bdl	bdl	-
Zn	12.4	13.33	7.5

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Table 3: Assessment of Sediments of Oron Channel based USEPA Sediment Quality Guideline for the Protection of Benthic Organisms

mg/kg dry weight

Metal	Not polluted	Moderately Polluted	Heavily Polluted	Concentration (2016)	Status
Cr	<25	25 -75	>75	6.32	Not polluted
Cu	<25	25 – 50	>50	0.28	Not polluted
Fe	<17000	17000 - 25000	>25000	198.43	Not polluted
Ni	<20	20 -50	>50	157.04	Heavily Polluted
Pb	<40	40 – 60	>60	0.034	Not polluted
Hg	<1.0	_	>1.0	> 0.01	Not polluted
Cd	_	_	>6	> 0.01	Not polluted
Zn	<20	90 – 200	>200	13.33	Not polluted

Table 4: Assessment of Sediments of Oron Channel using Consensus-Based Sediment Quality Guideline Values for Metals and Associated Levels of Concern

mg/kg dry weight

Metal	Level 1 Concern ≤ TEC	TEC	Level 2 Concern >TEC ≤ MEC	MEC	Level 3 Concern >MEC ≤ PEC	PEC	Level 4 Concern > PEC	Concentration (2016)
Cr	**Cr**	43	_	76.5	_	110	_	6.32
Cu	**Cu**	32	_	91	_	150	_	0.28
Fe	**Fe**	20,000	_	30,000	_	40,000	_	198.43
Ni	_	23	_	36	_	49	**Ni**	157.04
Pb	**Pb**	36	_	83	_	130	_	0.034
Hg	**Hg**	0.18	_	0.64	_	1.1	_	>0.01
Cd	**Cd**	0.99	_	3	_	5	_	>0.01
Zn	**Zn**	120	_	290	_	460	_	13.33

DISCUSSION

The concentration of Chromium (Cr), Copper (Cu), Iron (Fe), Nickel (Ni), Lead (Pb) Mercury (Hg), Cadmium (Cd) and Zinc (Zn) in the sediment was studied over a 2-year period. In the first year of the study (2015), the heavy metal concentration ranged as follows: Cr: 4.90 – 5.36mg/kg; Cu: 0.17 – 0.22mg/kg; Fe: 103.94 – 109.65mg/kg; Ni: 1.03 – 1.11mg/kg; Pb: 0.02 -0.02mg/kg; Zn: 12.02 – 12.67. Hg and Cd concentrations were below the instrument detection limit of 0.001mg/kg. In the second year (2016), the concentration of heavy metals ranged over the following values: Cr: 6.09 – 7.16mg/kg; Cu: 0.129 - 0.33mg/kg; Fe: 196.23 – 199.02mg/kg; Ni: 156.26 – 158.63mg/kg; Pb: 0.02 – 0.045mg/kg; Zn: 13.04 – 13.52mg/kg. Hg and Cd were below the detection limit of 0.001mg/kg (Table 1). The mean metal concentration in the years 2015 and 2016

was in the order: Fe > Zn > Cr > Ni > Cu > Pb and Fe > Ni > Zn > Cr > Cu > Pb respectively.

In the first year of the study, Fe, Zn and Cr had overwhelmingly higher concentrations compared to the other heavy metals. There was however a notable increase in Nickel concentration by the second year (Figure 2)**.**There was an increase in mean concentration of all the heavy metals in the sediment between the first and second years. Zinc had the lowest percentage increase of 7.5% and Ni the highest increase of 14,576.64% (Table 2).This dramatic increase in concentration of all heavy metals is probably due to recent anthropogenic input within the period under consideration.

Assessment based on the United States Environmental Protection Agency (USEPA) sediment quality guideline (SQG) for the protection of benthic organisms slowed that the sediments were "Heavily polluted" with Ni in the second year of study compared to a status of "Not polluted" in the first. The sediment was considered "Not polluted "for Cr, Cu, Fe, Pb, Hg, Cd, and Zn. (Table 3)

Using the Consensus-based Sediment Quality Guideline (CBSQG) which is an integrated combination of individual sets of guidelines developed by MacDonald *et al*, (2010), the concentration of Cr, Cu, Fe, Pb, Hg, Cd and Zn were below the 'Threshold effect concentration' (TEC) (Table 4). At such concentrations of the heavy metal in sediments, it is "unlikely" to cause harm to benthic dwellers. Only in Ni were the sediments found to have concentrations higher than the 'Probable Effect Concentration' (PEC). The 'Midpoint Effect Concentration' (MEC) is midpoint between TEC and PEC. Cr, Cu, Fe, Pb, Hg, Cd and Zn in the sediments were categorized as Level 1 Concern (≤ TEC) while Ni is of Level 4 Concern (> PEC). The levels of concern are qualitative descriptors that serve as a relative gauge of the potential impacts to the benthic species at that concentration of the contaminant [10].The levels Cr, Cu, Fe, Pb, Hg, Cd and Zn do not deleteriously impact the quality of the sediments. On the other hand the level of Nickel adversely impacts the sediment quality and is a probable cause of harm to benthic organisms.

Despite a notable increase in heavy metal concentration within the 2-year period spanning 2015 – 2016, the level of heavy metals in sediments of Oron channel was generally observed to be within tolerable limits with the exception of Nickel. The sharp increase in the concentration of heavy metals is an indication of possible anthropogenic activity. Using the USEPA Sediment Quality Guideline and the Consensus-based Sediment Quality Guideline and associated levels of concern, the sediments were observed to be heavily polluted with Nickel, constituting a probable harm to benthic organisms.

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