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METAL CONCENTRATIONS IN SEDIMENTS OF THE OGUN RIVER, NIGERIA
ความเข้มข้นของโลหะในดินตะกอนแม่น้ำโอกัน, ไนจีเรีย

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Abstract

Sediment samples were collected from various locations along the Ogun River basin after which they were subjected to physicochemical analysis in order to determine the concentration of metals in the sediments as well as other sediment characteristics like pH, texture, cation exchange capacity etc. The samples were collected using a Van Veen Sediment grab after which they were stored in labeled polythene bags and transported in ice packed coolers to the laboratory. They were air dried, sieved and hand pulverized. Sediment trace metal analysis was determined using the Inductively Coupled Plasma Optical Emission Spectrometry. Data obtained were subjected to Analysis of Variance (ANOVA). From the results obtained, Cd (1.00 ppm) from Lafenwa sediment exceeded the Environment Canada Sediment Quality Guideline (ECSQG) limit of 0.60ppm. Pb values from Akin Olugbade (46.00), Lafenwa (323.00 ppm), Copper (46.00 ppm) from Lafenwa, sediment Hg values obtained ranging from 0.945-0.975 ppm were all reported to be higher than the ECSQG limits of 35ppm for Pb, 35.7 ppm for Cu and 0.17 ppm for Hg respectively. There is need to monitor Cd values in sediment, from all the locations particularly Lafenwa so that appropriate measures can be put in place to reduce increase in Cd concentrations in the Ogun River basin especially from anthropogenic sources such as indiscriminate dumping of wastes into the river. Other metals like Pb, Cu and Hg should also be monitored frequently.

Keywords: sediment concentration, Ogun river

บทคัดย่อ

ทำการเก็บตัวอย่างดินตะกอนจากสถานที่ต่างๆ ตามลุ่มน้ำโอกัน หลังจากนั้นทำการวิเคราะห์ทางฟิสิกส์เคมีเพื่อหาความเข้มข้นของโลหะในดินตะกอน รวมทั้งความเป็นกรดด่าง ความหยาบละเอียด ความสามารถแลกเปลี่ยนประจุบวก และอื่นๆ เก็บตัวอย่างโดยใช้ Van Veen Sediment grab และเก็บในถุงพอลีธีนมีฉลากและส่งไปยังห้องปฏิบัติการในถังน้ำแข็ง ทำการระเหยแห้งโดย

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ใช้อากาศ คัดผ่านตะแกรง วิเคราะห์โลหะปริมาณน้อยในดินตะกอนโดยใช้เครื่อง Coupled plasma optical emission spectrometry ข้อมูลที่ได้วิเคราะห์โดยใช้ ANOVA ผลการศึกษา แคดเมียม (1 พีพีเอ็ม) จาก Lafenwa เกินมาตรฐานคุณภาพดินตะกอนของสิ่งแวดล้อมแคนาดา (ECSQG) ซึ่งเท่ากับ 0.6 พีพีเอ็ม ตะกั่วจาก Akin Olugbade (46 พีพีเอ็ม) Lafenwa (323 พีพีเอ็ม) ทองแดง (46 พีพีเอ็ม) จาก Lafenwa ปรอท (0.945-0.975 พีพีเอ็ม) มีค่าสูงกว่า ECSQG ซึ่งเท่ากับ 35 พีพีเอ็มสำหรับตะกั่ว และ 35.7 สำหรับทองแดง และ 0.17 สำหรับปรอทตามลำดับ มีความจำเป็นที่จะต้องตรวจติดตามแคดเมียมในดินตะกอนจากทุกสถานที่เก็บตัวอย่างโดยเฉพาะ Lafenwa ให้มีมาตรการลดแคดเมียมที่เพิ่มสูงขึ้นในลุ่มน้ำโอกันจากแหล่งกำเนิดที่เกิดจากกิจกรรมมนุษย์ ตัวอย่างเช่น การยกเลิกการทิ้งของเสียลงสู่แม่น้ำ ควรได้ตรวจ ติดตามโลหะอื่นๆ เช่น ตะกั่ว ทองแดง และปรอท บ่อยๆ

คำสำคัญ: ความเข้มข้นในดินตะกอน, แม่น้ำโอกัน

Introduction

Sediments which are soil, sand, and mineral fragments, washed from land into water usually after rain or breakdown of bedrock materials, can serve as bottom sink for the accumulation of heavy metals[1, 2]. Sediments generally harbor metals that affect water quality when present in high concentrations. Once discharged into river bodies, heavy metals become associated with particulates through sorption mechanisms or chemical processes. Along the river banks, various wastes are dumped due to poor or inadequate refuse disposal systems. These wastes could be as a result of farming, industrial, or commercial activities along the Ogun River banks. As a result, some harmful or toxic metals are transported and allowed to settle down on sediments and exposed bedrock materials. Physicochemical characteristics of the river have been reported[3, 4]. These studies further analyze the pollution status of the river, however, literature on the Ogun River sediment is still lacking. It is therefore the aim of this paper to determine the physicochemical chtaracteristics of the Ogun River bottom sediment such as pH, Cation Exchange Capacity (CEC), organic matter, total organic matter, particle size distribution and trace metal concentrations.

Stream borne sediment directly affects fish populations by decreasing the penetration of light into the water. This affects fish feeding and schooling practices, and can lead to reduced survival. Suspended sediment in high concentrations irritates the gills of fish, and can cause death. It can also destroy the protective mucous covering the eyes and scales of fish, making them more susceptible to infection and disease. Sediment particles absorb warmth from the sun and thus increase water temperature. This can stress some species of fish. In high concentrations, suspended sediment can dislodge plants, invertebrates, and insects in the stream bed. This affects the food source of fish, and can result in smaller and fewer fish while settling sediments can bury and suffocate fish eggs. Sediment particles can carry toxic agricultural and industrial compounds. If these are released in the habitat they can cause abnormalities or death in the fish.

This research was carried out between April to October, 2008 along the Ogun River basin. The Ogun-River, located in Ogun-State, South West of Nigeria lies between latitude 6°35' and 8°58' North with Longitude 2°40' and 4°10' East. It rises from Iganran Hills, east of Shaki, Oyo state, South West, Nigeria (latitude 07°40' N and Longitude 03°20' E) [3]. The entire river basin (Ogun River) occupies an area of approximately 23,700 km^2 [5].

Sampling Area

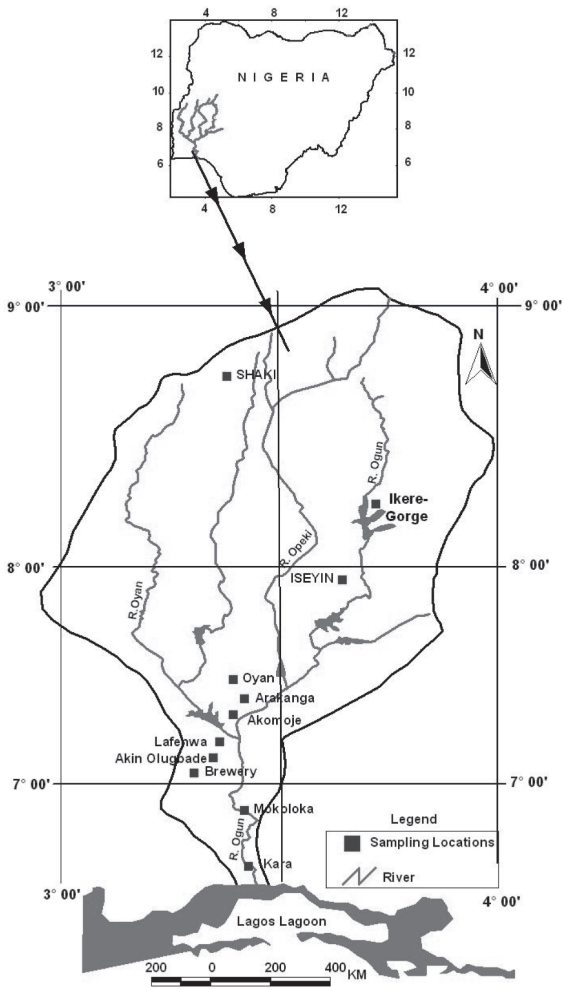

Figure 1 Map of the Ogun River

Ten sampling sites along the Ogun-River course namely; Mokoloki, Ikere, Iseyin, Brewery, Akomoje, Akin-Olugbade, Lafenwa, Oyan, Arakanga and Kara were surveyed.

Material and Method

Collection of Sample: Sampling was done on two occasions with three samples collected per location at each sampling season. Samples collected were composited for each location. Areas sampled such as Lafenwa, Brewery and Kara are located in places with high vehicular movements. Refuse of all kinds are dumped into the river section at Lafenwa while the presence of abattoir were observed at both Kara and Lafenwa. Ikere, Oyan, Arakanga, Akomoje and Mokoloki are situated in reserved areas where there are no much human activities. Predominant occupations around these areas include fishing and sand dredging. Sediments were collected from different sections of the Ogun River course between March and October, 2008. Sediment samples which were collected with the aid of a Van Veen sediment grab were transferred into polythene bags and placed in an ice chest for onward transportation to the laboratory.

Sample Preparation: At the laboratory, sediment samples were air dried, sieved using a 2 mm sieve to remove coarse particles. The finer sediments (i.e. 0 < 2mm) were taken for laboratory analyses.

Analytical Method: The samples were subjected to the Induced Couple Plasma Optical Emission Spectrometry (ICP/OES) for the determination of metal concentrations. Parameters like pH and electrical conductivity were using a HI 98129 Hanna Combo while the organic matter was determined using Black and Wakley method.

Data Analysis: Data obtained were subjected to Analysis of Variance (ANOVA) using SPSS (15) version while different means were separated using Duncan Multiple Range Test (DMRT) (P <0.05).

Quality Assurance: Three replicates were taken for every sample that was analyzed. A series of standard reference materials was used at the Activation Laboratory for bedrock and sediment samples. They include; GXR-1 Meas, GXR-1 Cert, GXR-2 Meas, GXR-2 Cert, GXR- 4 Meas, GXR-4 Cert, GXR-6 Meas, GXR-6 Cert.

Results

Table 1 Levels of physicochemical parameters of sediment samples obtained from the study area

Location	pH	Conductivity (µS/cm)	Organic Carbon (%)	Organic Matter (%)	Cation Exchange Capacity (meq/100g)				Particulate size distribution (%)			
					Na	K	Ca	Mg	Sand	Clay	Silt	Texture
Akomoje	7.8	93	32.0	55.04	1.30	1.03	6.0	0.6	100.0	0.0	0.0	Sandy
Akin Olugbade	8.4	74	18.0	30.96	6.09	1.03	2.0	0.2	100.0	0.0	0.0	Sandy
Arakanga	7.2	70	34.0	58.62	1.74	0.77	1.0	0.1	97.6	0.0	2.4	Sandy
Brewery	6.8	54	38.0	65.51	1.30	0.51	3.0	0.2	100.0	0.0	0.0	Sandy
Iseyin	6.5	35	18.0	31.03	0.87	0.01	2.0	0.3	100.0	0.0	0.0	Sandy
Ikere	6.8	30	8.2	14.14	2.17	1.03	3.0	0.6	79.6	12.0	8.4	Loam Sandy
Lafenwa	8.6	160	32.0	55.04	6.52	1.54	3.0	0.3	90.4	6.0	3.6	Sandy
Mokoloki	7.4	10	18.0	31.03	1.30	1.30	3.0	0.6	86.2	6.0	7.8	Loam sandy
Oyan	7.9	28	8.2	14.14	0.44	0.26	6.0	0.1	100.0	0.0	0.0	Sandy
Kara	7.9	64	32.0	55.04	10.30	10.30	2.0	0.2	88.0	6.0	6.0	Loam Sandy

Table 2 Duncan Multiple Range Test Analysis of the metal contents (ppm) of sediments obtained from the study area.

Location	Ag	Cd	Cu	Mn	Ni	Pb	Zn	Al
Mokoloki	0.196 ^{ab}	0.485 ^{b}	2.00 ^{h}	163.00^{h}	2.00 ^{g}	5.00 ^{g}	14.00 ^{g}	0.420 ^{e}
Ikere-Gorge	0.198 ^{ab}	0.465 ^{bc}	6.00 ^{g}	208.00 ^{f}	6.00 ^{d}	5.00 ^{g}	16.00 ^{f}	0.535 ^{d}
Iseyin	0.196 ^{ab}	0.470 ^{bc}	2.00 ^{h}	172.00 ^{a}	3.00 ^{f}	5.00 ^{g}	14.00 ^{g}	0.360 ^{f}
Brewery	0.196 ^{abc}	0.475 ^{bc}	7.00 ^{f}	140.00 ^{i}	2.00 ^{g}	15.00 ^{d}	28.00 ^{d}	0.200 ^{g}
Akomoje	0.197 ^{ab}	0.455 ^{c}	1.00 ^{l}	69.00 ^{j}	1.00 ^{g}	0.96 ^{h}	5.00 ^{i}	0.165 ^{h}
Akin Olugbade	0.197 ^{abc}	0.480 ^{b}	12.00 ^{d}	283.00 ^{c}	5.00 ^{e}	46.00 ^{b}	122.0 ^{b}	0.720 ^{b}
Lafenwa	0.196 ^{abc}	1.000 ^{a}	46.00 ^{a}	541.00 ^{a}	39.0 ^{a}	323.00 ^{a}	378.0 ^{a}	0.890 ^{a}
Oyan	0.195 ^{bc}	0.475 ^{bc}	9.00 ^{e}	241.00 ^{e}	9.00 ^{b}	10.00 ^{f}	13.00 ^{h}	0.370 ^{f}
Arakanga	0.195 ^{c}	0.485 ^{b}	18.00 ^{b}	282.00 ^{d}	7.00 ^{c}	18.00 ^{c}	26.00 ^{e}	0.360 ^{f}
Kara	0.195 ^{bc}	0.465 ^{bc}	14.00^{c}	328.00 ^{ab}	7.00 ^{c}	12.00 ^{e}	40.00 ^{c}	0.570 ^{c}
Ikere-Gorge	1.950 ^{b}	72.00 ^{a}	0.465 ^{b}	29.00 ^{b}	9.945 ^{ab}	0.955 ^{abc}	1.965 ^{b}	1.00 ^{c}
Iseyin	1.955 ^{b}	49.00 ^{g}	0.485 ^{a}	13.00 ^{h}	9.950 ^{ab}	0.965 ^{abc}	1.975 ^{b}	0.95 ^{f}
Oyan	1.950 ^{b}	61.00 ^{e}	0.485 ^{a}	17.00 ^{f}	9.170 ^{d}	0.950 ^{bc}	1.970 ^{b}	0.96 ^{d}
Lafenwa	11.00 ^{a}	72.00 ^{b}	0.475 ^{ab}	105.5 ^{a}	9.750 ^{bc}	0.970 ^{ab}	6.000 ^{a}	4.00 ^{a}
Brewery	1.945 ^{b}	32.00 ^{gh}	0.475 ^{ab}	14.00 ^{g}	9.965 ^{a}	0.975 ^{a}	1.965 ^{b}	0.95 ^{f}
Akin Olugbade	1.940 ^{b}	79.00 ^{a}	0.475 ^{ab}	18.00 ^{e}	9.750 ^{bc}	0.965 ^{abc}	1.965 ^{b}	2.00 ^{b}
Akomoje	1.960 ^{b}	31.00 ^{gi}	0.480 ^{ab}	13.00 ^{h}	9.750 ^{bc}	0.960 ^{abc}	1.980 ^{b}	0.96 ^{e}
Arakanga	1.965 ^{b}	63.00 ^{d}	0.475 ^{ab}	19.00 ^{d}	9.345 ^{d}	0.945 ^{c}	1.965 ^{b}	0.92 ^{g}
Mokoloki	1.960 ^{b}	56.00 ^{f}	0.485 ^{a}	17.00 ^{f}	9.960 ^{ab}	0.965 ^{abc}	1.980 ^{b}	1.00 ^{c}
Kara	1.960 ^{b}	67.00 ^{g}	0.470 ^{b}	22.00 ^{c}	9.700 ^{d}	0.965 ^{abc}	1.965 ^{b}	2.00 ^{b}

Note: Values with identical letters were not significantly different from each other at 95% confidence level when subjected to Duncan Multiple Range Test

Discussion

Table 1: From the results obtained, it was observed that sediment pH values of Brewery, Iseyin, and Ikere were acidic while sediment samples from Arkanga, Akomoje, Akin Olugbade, Oyan, Lafenwa and Kara all showed basic pH levels. Acidic pH can be ascribed to the introduction of acidic waste substances. Besides, bedrock could also accelerate acidic levels in sediments. Similarly, sediment alkalinity may be associated with bedrock particularly those that have high calcium carbonate content. Particle Size Distribution analysis

showed that, Akomoje, Akin-Olugbade, Arakanga, Brewery, Iseyin, Lafenwa and Oyan sediments were sandy while loamy sandy sediments were observed in Ikere, Mokoloki and Kara. The highest organic matter value was obtained at Brewery (65.51%) while the lowest were observed at Ikere and Oyan (14.14% respectively). Similarly, the highest organic carbon value was obtained at Brewery (38%) while the lowest were observed at Ikere and Oyan (8.2% respectively). Lafenwa sediments, had more electrical conductivity value (160 μS/cm) than the other nine stations surveyed while Mokoloki Electrical conductivity (10 μS/cm) value was observed to be the lowest. High conductivity is an indication that there are a good number of dissolved inorganic substances in a sample. Elevated dissolved solids can cause mineralized taste in water.

Table 2: Lafenwa Cd (1.0 ppm) was higher than the Environment Canada Sediment Quality Guideline standard of 0.6 ppm. Cadmium could have been deposited into river sediments from battery discharge due to the activities of battery chargers within the Lafenwa area. Similarly, Cu concentration at Lafenwa (46 ppm) was higher than ECSQG standard of 35.7 ppm. Akin Olugbade and Lafenwa Pb values for sediment (46 ppm and 323 ppm respectively) were reported to be high compared to the ECSQG standard. All Hg values were reported to be higher than the ECSQG (0.17 ppm). This could result to Hg toxicity in sediments in the areas sampled. Zn and Cr values from Lafenwa (378.0 ppm and 105.5 ppm) were also reported to be higher than the ECSQG standards of 123 ppm and 37.3 ppm respectively. Mercury causes brain and central nervous system damage, congenital malfunction and development changes in young children [6]. Lead values obtained ranged from 5 ppm (Mokoloki, Ikere and Iseyin) to 323 ppm (Lafenwa) while the ECSQG standard is 35 ppm. This shows that the Lafenwa section of the Ogun River and Akin Olugbade (46 ppm) have very high lead concentrations. Lead toxicity could lead to damages to the nervous system, kidney and liver of birds and mammals and it can lead to sterility, growth inhibition, developmental inhibition and detrimental effects in blood [7]. Arsenic which is found in all living matter[8] was analyzed in the course of this study and it was observed that all values obtained (for Arsenic) were lower than the ECSQG standard of 5.8 ppm except the one obtained from Lafenwa (11 ppm). Long-term arsenic concentration leads to thickening and discoloration of the skin, nausea and diarrhea, decreased production of blood cells, abnormal heart rhythm and blood vessel damage [9].

Chromium (Cr) results showed that all values obtained from this research were lower than the ECSQG standard (37.3 ppm) except that obtained from Lafenwa (105.5 ppm). The least Cr value of 7 ppm was obtained from Oyan. Chromium is an essential trace element which can be toxic to biota at elevated concentrations. ATSDR[10] stated that a wide range of adverse effects were observed in aquatic organisms, e.g. reduced fecundity, growth inhibition, chromosomal aberrations and abnormal movement patterns when exposed to high Chromium levels.

Conclusion

From the study carried out, it can be inferred that Akomoje sediment had low values for most of the trace metals analyzed such as Cd (0.455 ppm), Cu (1.00 ppm), Ni (1.00 ppm), Pb (0.96 ppm), Zn (5.00 ppm), Al (0.165 ppm), Ba (31.00 ppm) and Cr (13.00 ppm). This indicates low threat of metal toxicity in this area. While Lafenwa sediment showed the highest concentrations of trace metals like Cd (1.00 ppm), Cu (46.00 ppm), Mn (541.00 ppm) , Ni (39.00), Pb (323.00 ppm), Zn (378 ppm), Al (0.890 ppm), As (11.00 ppm), Cr (105.5 ppm), Sb (6.00 ppm) and Sc (4.00 ppm). Thus sediments from Lafenwa are at a higher risk of toxicity for the aforementioned metals than all the other areas analyzed. These trace metals can have deleterious effects on aquatic organisms and on the health of humans who rely on the water from the rivers where the sediments are situated. Sediments can release metals into the river water as a result of turbulence and resuspension. Effective monitoring is therefore required for the Lafenwa section of the Ogun-River and other areas where trace metal values were higher than the Environment Canada Sediment Quality Guideline. Proper waste disposal systems and laws against indiscriminate dumping of refuse/wastes from municipal and industrial areas should be put in place.

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