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Assessment of the Heavy Metals Concentration of Nkesa River, Rivers State, Nigeria

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Abstract

The growing concern on the safety of the inhabitants and users of the Nkesa River for different purposes, ranging from consumption, domestic activities and others too numerous to mention, necessitated the assessment of heavy metal concentrations of Nkesa River, Rivers State Nigeria. Concentrations of ten (10) different metals namely: Copper, Zinc, Iron, Cadmium, Chromium, Lead, Mercury, Vanadium, Manganese and Arsenic, from three (3) different sites of the river, namely: Mgbede, Okwuzi and Aggah, based on proximity to effluents, were analyzed using the Varian AA240 Atomic Absorption Spectrophotometer according to the method of APHA 1995 (American Public Health Association). The study aimed to access the varied toxicity of these metals on both the inhabitants and other secondary users. Data obtained for heavy metals analysis, showed that Iron, Lead and Mercury, were above the maximum contaminant levels (MCLs) of USEPA (2010) and WHO (2004). The waters of Nkesa River is therefore, declared unfit for direct human consumption, as this would lead to Fe, Pb and Hg related illnesses; therefore posing potential risk of bio-magnification for inhabitants that depend on the river. It is therefore recommended that, an urgent need to properly manage wastes in the cities and monitor anthropogenic activities, is of great importance in order to ensure minimized effects on these parameters of Nkesa River. Sensitization should be carried out, to educate the people on the dangers of its ingestion.

Keywords: Aggah, anthropogenic, atomic absorption spectrophotometer, biomagnification, heavy metals, Mgbede, Nkesa River and Okwuzi.

Introduction

Water is an elixir of life and abounds on earth but this vast natural resource, has been depleted and turned into a scarce commodity with increased usage, catering to the needs of ever dependent and expanding population. There is almost a global shortage of water and ranked as world's most urgent need especially as it relates to supply and maintenance of clean water [1]. Rivers are used for a variety of purposes such as drinking, washing, bathing, recreation as well as numerous other varied industrial applications. The wholeness of these water bodies has become an issue of great concern. Rivers are the most important freshwater resource for man.

Unfortunately, river water is constantly being polluted by indiscriminate disposal of sewage, industrial wastes and plethora of human activities, which adversely affects their physicochemical properties, including microbiological quality content, which has become a serious growing problem. The increasing amount of industrial and municipal wastes that are being discharged into rivers, has led to various deteriorating effects on aquatic animals, hence the accumulated pollutants are transferred into the body system causing diseases and infections [2].

Contamination of rivers by heavy metals may have catastrophic effects on the ecology balance of aquatic life and the diversity of aquatic organisms which could be limited by the extent of the contamination [3]. The study of water pollution is very important to keep humans in heath. The fresh water, is essential to human but it is becoming a limited resource due to the influence of population growth, pollution and global warming [4]. Heavy metals are metallic elements with high atomic weight and density. These include the transition metals, some metalloids, lanthanides and actinides. Amounting to more than 20 metals generally exist in a positively charged form and can bind on to negatively-charged organic molecules [5].

Being metals ions, heavy metal cannot be degraded or destroyed, therefore their stability makes them serve as persistent toxic substances in environment. Heavy metal as the environmental contaminants can be found in the air, soil and water, which pose health hazard to the general public.

Expeditious expansion and industrial development near the rivers, have led to more stress on the river and with increased stress, the water becomes polluted and worsening environmental health, is observed [6]. Water functions as a medium of transport for pollutants and they can be damaging to both living organisms and the environment [7]. Heavy metals constitute a natural trace component of the aquatic environment, whose levels have been reported to be on the increase in recent times, due to pollution from industrial wastes, changes in geochemical structure, agricultural and mining activities [8, 9].

Unlike organic contaminants, heavy metals are not degraded with time, but concentration can only increase through bioaccumulation [10]. From a human health perspective, mercury, arsenic, cadmium and lead have been identified as primary contaminants of concern [11]. These metals have no biological importance in human biochemistry and physiology, but its consumption, even at very low concentration can be toxic [12]. Even for metals with bio-importance such as zinc, nickel and chromium [13], dietary intake has to be maintained at the regulatory limits, as excesses will result in poisoning or toxicity [14].

This is because they combine with body biomolecules such as metal-binding protein and enzymes to form stable biotic compounds, thereby mutilating their structures and hindering them from performing the designated functions within the body system [15]. Heavy metals naturally enter, and are distributed in the environment through several natural processes such as volcanic eruptions, spring waters, erosion, bacterial activity and anthropogenic activities [16]. These metals do bio accumulate in living organisms and the human body through various processes causing adverse effects. In the human body, these heavy metals are transported and compartmentalized into body cells and tissues binding to proteins, nucleic acids destroying this macromolecules and disrupting their cellular functions. It can also affect the central nervous function, leading to mental disorder, damage the blood constituent and may damage the lungs, liver, kidneys and other vital organs, promoting several disease conditions [17].

Acute exposure to high concentration of heavy metal can cause nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis. From the perspective of human health, each of the heavy metal imparts different effects and symptoms [18].

Therefore, this study aimed to access the concentration of ten (10) heavy metals from three (3) different sites of Nkesa River, namely; Mgbede, Okwuzi and Aggah.

Materials and Methods

Description of Study Area

The study was carried out at Nkesa River. It is located in Ogba Egbema Ndoni Local Government Area of Rivers State in the Niger Delta Region of Nigeria, and lies between latitude $5^{0}27'32.5''$ N and longitude $6^{0}42'38.1''$ E as shown in Fig.1. It is a tidal dominated river, with possible fresh water input.

The source of Nkesa River is the Orashi River (its source is the rocks of Ezeama community of Dikenafai, Imo State which is 183m above mean sea level) which flows through communities like Urualla, Ozubulu, Oguta, Opuoma, Mmahu, Abacheke, Omoku, Mgbede, and Epie before emptying into the Atlantic Ocean [19]. The anthropogenic activities taking place within the region are agriculture (farming, palm oil production) and offloading of petroleum products (bunkering).

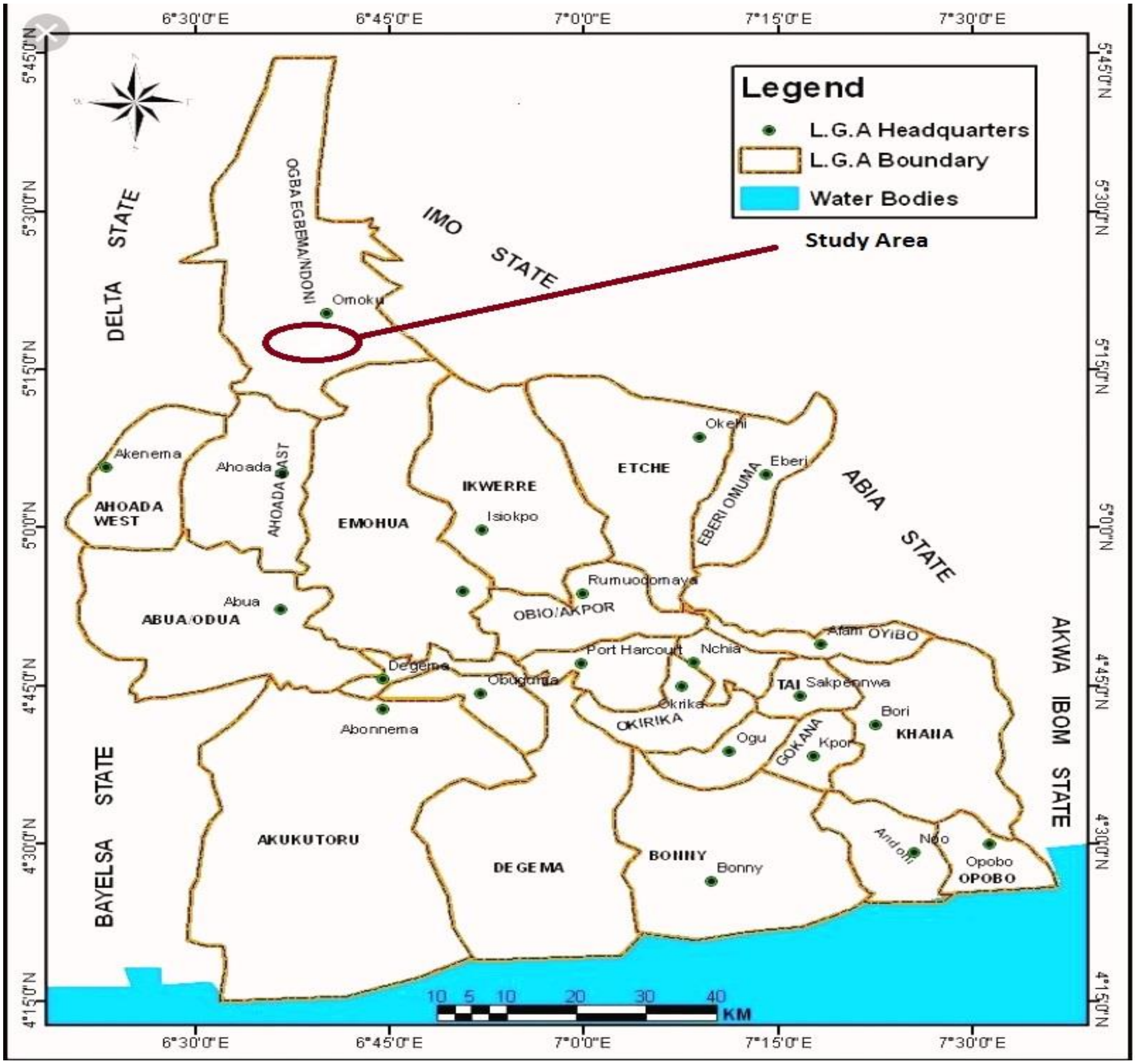

Fig.1: Map of River State showing the study area. (Source; Google)

Sample Collection and Elemental Metal Analysis

The samples were collected at the three different sampling points (Mgbede, Okwuzi and Aggah) with 35cl plastic containers, which were previously washed and rinsed with distilled waterand for metal analysis, they were treated with 1ml of Hydrochloric acid (HCl) in 100 cm^3 sample to arrest microbial activities. Digestion of water samples was carried out using pre-concentrated Nitric acid method. Metal analysis was conducted using Varian AA240 Atomic Absorption Spectrophotometer according to the method of APHA 1995 (American Public Health).

The heavy metal concentrations were estimated using Atomic Absorption Spectrophotometric (AAS) method after acid digestion. The data generated were compared with World Health Organization (WHO, 2004) standards for drinking water.

Reagents/Apparatus

All reagents used were of analytical grade. Deionized water was used for solutions preparation and dilutions. All glass wares were soaked in 10% HNO_3 for two hours and later rinsed with distilled de-ionized water prior to use for quality assurance of the determinations. Ultrapure standard solutions of 1000 mg L^{-1} of the metals (Merck, Darmstadt, Germany) were used for calibration. Nitric acid (65%) and hydrogen peroxide (30%) of ultrapure quality for digestion were from same source.

Statistical Analysis

The data was subjected to One way ANOVA Analysis using SPSS for the various parameters. Further test such as Duncan's multiple range tests was carried out to ascertain whether there is significant difference among the parameters. The data was analyzed using the Statistical Package for Social Sciences 6.5 windows application.

Results and Discussions

Table 1: Heavy metals concentration of water samples collected from Nkesa River

Parameters (mg/l)	Mgede	Okwuzi	Aggah	WHO (2004)	EPA (2010)
Copper	0.09 ± 0.00^a	0.06 ± 0.00^b	0.10 ± 0.00^c	1.5	1.3
Zinc	0.08 ± 0.00^a	0.07 ± 6.00^b	0.07 ± 0.00^c	5.0	5.0
Iron	0.28 ± 0.00^a	0.29 ± 0.00^b	0.47 ± 0.00^c	0.3	1.0
Cadmium	0.05 ± 0.00^a	0.05 ± 0.00^a	0.06 ± 0.00^c	0.005	0.005
Chromium	0.01 ± 0.00^a	0.00 ± 0.00^b	0.02 ± 0.00^c	0.05	0.05
Lead	0.04 ± 0.00^a	0.07 ± 0.01^b	0.06 ± 0.00^c	0.01	0.015
Mercury	0.09 ± 0.00^a	0.09 ± 0.00^a	0.08 ± 0.00^b	0.001	0.002
Vanadium	6.01 ± 0.00^a	0.00 ± 0.00^b	0.02 ± 0.00^c	-	0.05
Manganese	0.01 ± 0.00^a	0.01 ± 0.00^a	0.02 ± 0.00^b	0.05	0.03
Arsenic	ND	ND	ND	0.05	0.01

Note: Results are means ± standard deviation of means of the samples.
Means that share alphabets are not significantly different
ND = Not detected

The summary of the values of the heavy metals obtained from the three Sites in Nkesa River is as shown in Table 1 above. When compared with WHO (2004) and USEPA (2010) guidelines, the result shows that Copper (Cu) was low in all the sampled sites. It fluctuated between 0.06±0.00mg/l and 0.10±0.00mg/l. The lowest value was observed in Okwuzi (0.06±0.00 mg/l) while the highest value was observed in Aggah (0.10±0.00mg/l). Zinc (Zn) ions reduced gradually with the highest value in site 1 (0.08±0.00 mg/l) and similar value in Okwuzi (0.07±0.00 mg/l) and Aggah(0.07±0.00 mg/l). Concentration of iron showed some variations in all three sampled sites. It ranged from 0.28±0.00 to 0.47±0.00 mg/L. Generally, the results of iron were higher than the other metals sampled in all Sites.

From the result, concentration of Cadmium (Cd) was low, the lowest value (0.05±0.00 mg/L) was observed in Mgbede and Okwuzi while the highest value (0.06±0.00 mg/L) was observed in Okwuzi. Chromium (Cr) and Vanadium (Vn) resulted to same values in all three sites ranging from 0.00±0.00 to 0.02±0.00 mg/L. Lead (Pb) ranged between 0.04±0.00 to 0.07±0.00 mg/L. The lowest value was observed in Mgbede (0.04±0.00 mg/L) and the highest value was observed in Okwuzi (0.07±0.00mg/L). The concentrations of Mercury ion were similar in all three Sites. From the result, concentration of Manganese (Mn) was low in all three sites ranging from 0.01±0.00 to 0.02±0.00 mg/L.

Metals are serious pollutant of the aquatic environments. Heavy metals found in plant and animal can cause harmful effect to human health, when taking in as food [20]. This metal is carcinogenic and is usually taken by inhalation; it is also, corrosive to tissue. It is used in alloys, electroplating, pigments, paint manufacture, fungicides, glass, leather tanning industries and photography [21].

Copper (Cu) is an essential substance to human life, but chronic exposure to contaminant drinking water with Cu can result in the development of anemia, liver and kidney damage [22]. On the other hand, lack of copper intake causes anemia, growth inhibition, and blood circulation problems [23]. Zinc (Zn) is present in large amounts in natural water [24]. The mean concentrations of 0.06±0.00 to 0.10±0.00 mg/L for Cu was far below the MCL of WHO (2004) and USEPA (2010)

Discussion

The study showed that the concentration of Arsenic (As) is below detectable limit of the referenced values of WHO in all the sampled stations, and also below US EPA. Cadmium (Cd) is above the reference value (WHO). The permissible limit of Cd in water, recommended by WHO, is 0.005 mg/L. Chromium (Cr) concentrations in the three stations are below the reference value. According to the EPA guideline for heavy metal in water, the sampled sites are unpolluted with chromium. The values recorded during this investigation were lower for all the sampled stations. The values are compared to similar studies undertaken by Onjefu *et al*. 2016 [25]. However, these concentrations of

Cr were higher than the levels of 0.25 to 1.68 mg/L in the Benin River, Nigeria [23].

The concentration of Lead (Pb) recorded was above WHO and indicates that the region of site Okwuzi and Aggah were heavily polluted; site 1 is moderately polluted according to EPA heavy metal guidelines for River water (Table 1). Lead (Pb) as a soil contaminant is a global issue; it accumulates with age in bones, aorta, kidneys, spleen and liver. This metal can enter the body through uptake of food, water and air. The concentration of lead in this study was lower than the values (11.8 to 39 mg/L and 14.0 to 22.1 mg/L) obtained by Saikia*et al.* (2014) in the samples of the Subansiri River respectively [26]. The mean concentration of Manganese (Mn) in this study was 0.01.00±0.00 to 0.02±0.00 mg/ L. In all the sampled sites, Mn was found to be lower than 0.05 mg/L recommended limit for Mn in water (USEPA, 2010). Nkesa River is contaminated by Iron (Fe). The mean value of 0.47±0.00 mg/L recorded in this study exceeded the maximum contamination level (MCL) of < 0.03 recommended by WHO (2004) and less than the MCL<1.0 recommended by USEPA (2010), respectively.

The mean concentration of Mercury (Hg) 0.08±0.00 to 0.09±0.00 mg/L was higher than the permissible limit WHO (2004) and USEPA (2010). Vanadium (Vn) concentrations ranged between 0.01±0.00 mg/l to 0.02±0.00 mg/l. The majority of water sample have vanadium in the 0.00 to 0.02 mg/l band, which was below the 0.05mg/l limit USEPA (2010).

Conclusion

From the result of the data obtained for heavy metals analysis of Nkesa river, Fe, Pb and Hg were above the maximum contaminant levels (MCLs) of USEPA (2010) and WHO (2004). The waters of Nkesa River is therefore, declared unfit for human consumption as this would lead to Fe, Pb and Hg related illnesses, therefore posing potential risk of bio-magnification for inhabitants that depend on the river. The result of the research is valuable in informing the populace of the health risks associated with contaminated water bodies.

Recommendation

It is therefore recommended that, there is an urgent need to properly manage wastes in the cities and monitor anthropogenic (human) activities in order to ensure minimized effects on these parameters of Nkesa River. Sensitization should be carried to educate the people on the dangers of ingestion. The need for constant monitoring of the levels of contamination to assess the impact of the heavy metals cannot be underestimated.

Further study on the concentrations of hydrocarbons should be carried out in consideration to oil spillage in the area. This is necessary since the river serves as a source of drinking water, irrigation and fisheries for the local inhabitants.

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