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Evaluation of Heavy Metals Concentrations in Private Pipe Borne Water from Designated Flooded Areas in Parts of Rivers State, Nigeria

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Abstract

Water is one of the most important resource available to man. Therefore, several studies had been done and many on the way to find out the worth of consumable water with respect to the determination of the concentration of heavy metals present. This study was done to assess the concentration of heavy metals in selected tap water used for drinking from selected Local Government Headquarters in Rivers State, Nigeria. Tap water samples were collected from Tai, Obio/Akpor, Port Harcourt, Oyibo and Eleme Local Government Areas (LGA) of Rivers State, Nigeria. A composed six water samples were taken from each LGA. The samples were then examined for heavy metals which include cadmium (Cd), lead (Pb), arsenic (As) and iron (Fe). The results of the analysis in all the examined stations showed lower values than those of SON, USEPA, EU and WHO. During dry season, Cd values varied from 0.0004 to 0.0008 mg/L, Pb values ranged from 0.0004 to 0.004 mg/L, As varied from 0.0002 to 0.004 mg/L and Fe was detected only at Oyibo at a value of 0.80 mg/L (which was higher than the required value of 0.3 mg/L by the different regulatory bodies. In the rainy season, the concentrations of all the metals (Cd, Pb and As) with the exception of Fe were in all the of the same value of 0.001 mg/L, while Fe was undetected in all the samples. The obtained results showed that the water is good for drinking based on the examined heavy metals results. The low values of all examined heavy metals is owing to the absence of industrial activities within the areas samples were obtained. However, the portability of the water should be proved first after due consideration of other important water quality parameters.

Keywords: tap water, heavy metals, flooded areas, water quality, contamination

INTRODUCTION

Viable water supply is very important to man, plants and animals. It is very vital in food preparation, provision of hygiene, maintenance of suitable public health, washing of household utensils, toiletries and heavy duty mechanical equipment. In general, water from tap is considered to be safe because it is subjected to conventional management and treatment which follows stipulated steps such as coalescence, sedimentation, clarification and decontamination. Yet, it can correspondingly remain a basis for contamination by chemical and biological substances (Corpuz, et al., 2016; Alambatin et al., 2017). Improper practices of water sanitation procedures in most developing countries notably adds to certain percentages of death among children and stomach ailments among adults (WHO – GHO, 2016). A huge quota of sickness and death arising from water intake is due to the presence of pathogens in fecal depositions that may have found their way into the water and also the presence of chemical substances that moved from soil to water (Flink, et al., 2011). Water in its uncontaminated form is neutral, without smell, has no colour and do not give taste. However, humanoid activities as well as those of animals has tremendously contaminated it with both solid and liquid waste (arising from effluents generated from substance based productions and soluble fumes (Jimoh and Umar 2015).

On one hand, heavy metals in water can be absorbed into the body as a result of dermal contact and can be raised to levels which can cause neurotoxic effects and thus cause behavioural complications, reduced physical and mental aptitude (Kippler & Tofail, 2012). The definition of heavy metals is based the comparison of its relative density being higher than that of water (Jamshaid et al., 2018). This definition is based on the supposition that the mass and poisonousness are interconnected. Heavy metals as a group has been enlarged to include metalloids like arsenic that has the ability to prompt toxicity at trace level of contact. Nowadays, there is a growing interest on the upsurge of environmental and worldwide fear on the issue of illnesses connected with environmental adulteration by way of the presence of these metals (Nachana'a and Ezekiel, 2019).

Even though heavy metals are of natural occurence in all the spheres of the globe, yet elevation to hazardous concentrations in the environment is a resultant effect from human interference with nature. These human based activities include, sand dredging (Iyama and Edori, 2014), oil exploration and exploitation (Edori and Edori, 2021), production of goods and services in the industries (Lavanya et al., 2021), mining, excavation and smelting operations, and home use of metals and their allied combinations (Tchounwou et al., 2012). Other foundations of human environmental input of heavy metals are oil bunkry, oil spillage and transportation of goods and services. According to Solayman et al. (2016) heavy metals are also referred to as trace elements because they are always existing in very minute concentrations in different environmental milieus.

The obtainability of water with acceptable quality is an obligatory characteristic required for the prevention of infections and improving the value of existence (Adefemi & Awokunmi 2007). Umar (2015) observed that numerous number of these metals are essential as micro-nutrients. The quantity of essential elements in water differ due to bodily, conservational and additional extraneous reasons (Sa'id, 2008). Specific trace components or substances play numerous roles in biological entity of which a number of them are indispensable constituents of enzymes where they draw substrate particles to themselves and expedite transformation to particular end product (Nielson, 2002). Despite their importance, when present in too much concentrations, essential elements has the ability to destructively upset growth, replication and additional natural roles of living organisms. Any water to be consumed domestically or industrially must be safe and portable and should follow stipulated national or international standards such as SON and WHO (Okedi, 1997).

A flood is an excess run-off of water (or seldom additional solutions) which immerses or sinks land. It is typically caused by human interference with the environment and also may be natural. Human intrusion into the surroundings time and again escalates the strength and rate of recurrence of flooding (Farida & Maswanku, 2022). Such influences may include forest loss and elimination of swamps, alterations in watercourse or flood management such as with embankments, and bigger environmental matters like climate change and rise in sea water. When flooding takes place, it is accompanied by redistribution of different chemical agents, plant and migration of animals. Therefore this study was undertaken to examine the concentrations of some heavy metals in tap water in flooded areas of selected LGA in Rivers State.

Materials and Methods

Study Area

The study focuses on several areas within Rivers State, Nigeria: Eleme, Obio-Akpor, Oyigbo, PHALGA (Port Harcourt Local Government Area), and Tai. Each area's geographical coordinates

(latitude and longitude) are provided, showcasing their respective locations: Eleme (Latitude: 4.8870° N, Longitude: 7.0296° E), Obio-Akpor (Latitude: 4.8362° N, Longitude: 7.0131° E), Oyigbo (Latitude: 5.0660° N, Longitude: 7.4603° E), PHALGA (Port Harcourt Local Government Area) (Latitude: 4.8181° N, Longitude: 7.0374° E), and Tai (Latitude: 4.6198° N, Longitude: 7.3603° E).

Sample Collection

An overall number of fifty samples were composed, 5 from each LGA. Twenty five during the raining season and twenty five all through the dry period. These water samples were taken in 75cl sterile containers. Preceding time for sample collection, all the containers were cleaned with the similar water to be obtained from the borehole water. The sample vials or containers were branded with date and assortment sites. The caps of the bottle were aseptically removed and sample bottles were kept an inch away from the tap avoiding contamination while collecting the sample. The sample vials were covered aseptically.

The samples were maintained at 4oC in a preservation pack and conveyed to the analytical laboratory within 2 hours for instant sample investigation. These sampled waters were collected from; Eleme, Obio-Akpor, Oyigbo, PHALGA, and Tai.

Heavy Metals Analysis

The heavy metals were analyzed using APHA 3111C method. After the digestion of the samples with HNO_3, the heavy metals were investigated by means of PG Scientific Instrument Atomic Absorption Spectrophotometer (AAS).

Data Analysis

The data were tested by means of analysis of variance to define the level of impact between seasonal variations in heavy metals concentrations

Results and Discussion

The levels of heavy metal levels in pipe borne water in dry and rainy periods among local government areas is shown in Tables 1 and 2.

Cadmium (Cd)

The results revealed that there was no significant disagreement (F-value = 0.5; p-value = 0.74) in the mean levels of cadmium among Tai (0.0008), Obio/Akpor (0.0006), Phalga (0.0006), Oyibo (0.0004) and Eleme (0.0004) local government areas during dry season. Also, there was no significant difference (F-value = n/a; p-value > 0.05) in the mean levels of cadmium among Tai (0.001), Obio/Akpor (0.001), Phalga (0.001), Oyibo (0.001) and Eleme (0.001) local government areas during rainy season.

The determined values of Cd in the study from all the examined location indicated lower than SON, WHO, USEPA and EU requirement values for water to be consumed. The present work values of Cd were lesser than the values of Liu et al. (2023), Solidum and Solidum (2012) and Edori and Kpee (2016) in tap water from Wuhan City, China, Manila, Philippines and abattoir in Port Harcourt, Nigeria respectively.

Cadmium is a very toxic metal. It is used in the manufacture of Ni-Cd arrays. When an individual is exposed to lingering levels of Cd, it leads to a wide-ranging variation of severe and prolonged effects. Human tissues usually accumulate Cd. The accumulation of Cd in the kidney results in life-threatening health effect (kidney destruction) referred to as renal tubular damage. Additional effects of Cd contact include disorders in Ca uptake, hypercalciuria and the development of kidney grits (Idrees et al., 2018). Contact with Cd is central factor in lung cancer and prostate cancer cases. Therefore, water supply which contains Cd may result in fatality and hence has become a worldwide menace. The presence of Cd in water is by natural means and human activities or both. These sources include; soil wearing away, weathering of the earth's crust, mining, industrialized wastes, metropolitan overflow, sewages release, pesticides applied to crops (Pandey & Madhuri, 2014).

When a high level of cadmium has been identified, proper actions should be taken to safeguard people from drinking such water (Rehman et al., 2018). Reduced level of contact with cadmium has the propensity to cause a drop in bone density and alter its composition (Buha et al., 2019). Since children's bones are rapidly growing, they are most delicate and more at risk to Cd intake. Cd is usually stored up in the kidney and do not easily undergo disintegration and cannot be mobilized in the kidney (Nordberg et al., 2018), therefore, both chronic and acute exposures can lead to lifetime disorders (Ekong, et al., 2006; Jiang et al., 2015).

Natural source of Cd into air, water and soil are volcanic eruptions and forest fires, while human sources are mining, industrial production, throwing away of wastes, phosphate fertilizers, burning of fossil fuel. (Weldeslassie et al., 2018). Although Cd is scarcely found in nature, yet they are existent in soil and natural resources such as sulfide, sulfate, carbonate, chloride, and hydroxide salts and in water.

Lead (Pb)

The results disclosed that there was no significant variation (F-value = 0.65; p-value = 0.63) in the average values of Pb among Tai (0.001), Obio/Akpor (0.004), Phalga (0.002), Oyibo (0.0004) and Eleme (0.0002) local government areas during dry season. Also, there was no significant difference (F-value = n/a; p-value > 0.05) in the average values of Pb among Tai (0.001), Obio/Akpor (0.001), Phalga (0.001), Oyibo (0.001) and Eleme (0.001) local government areas during rainy season.

The determined values of Pb in the study from all the examined location were lesser than the SON, WHO, USEPA and EU requirement values water meant for consumption. The values of Pb obtained from the different tap water from the studied location were in the same value range detected in tap water from thirty two Turkish Cities by Bozkurt et al. (2016) and also within the values of Darylle and Ruby (2021) in tap water provided for some public schools in Muntinlupa City, Philippines. However, the values were slightly greater than the values of Sulaiman et al. (2023) in tap drinking water from a temperate residential region of Jengka, Malaysia.

Lead is naturally a known noxious metal present in water and soil. Its extensive occurrence has caused broad ecological contamination, human contact and substantial public health complications all over the world (Morais et al., 2012). One way that Pb infiltrates into drinking water sources is through a chemical reaction that occur in Pb containing pipes. Lead infiltration of this type is referred to as corrosion enhanced dissolution metal from pipes and fittings. In very high acidic medium, this reaction becomes more (Naja & Volesky, 2017). When humans ingest Pb into the body, it is quickly circulated to functional organs like the brain, kidneys, liver and bones. Teeth and bones have been observed to accumulate Pb. During pregnancy, accumulated lead in body organs and tissues may be transferred the fetus (Bandyopadhyay et al., 2014).

Malnourished children are more at risk to lead toxicity due to the fact that their bodies absorb extra lead in the absence, lack or scarcity of mineral nutrients like calcium or iron. In general, no harmless blood value has been known for infants and young children. Therefore, all the ways by which children can contact lead should be put under check or totally eradicated. Due to its toxicity, WHO has recommended zero tolerance of lead in portable or drinking water. Pb is an unsafe environmental pollutant which displays lethal effects to numerous body part in the living system. It can prompt nervous, respirational, urinary and heart maladies owing to immune variation, redox and swelling mechanisms. Contact with Pb may be able to produce modification in bodily roles and is linked to a lot of ailments (Joseph et al., 2005). It is extremely poisonous and have hostile effects on neural, biological and intellectual capacity in the body. The global level of concern for Pb poisoning in blood is 10μg/dl (Burki, 2012).

Risk associated with Pb contact differ subjectively based on individuals, the chemical environments of the water, and the amount consumed. However, bathing and showering seem to be safe for humans because human skin do not absorb lead in water (Triantafyllidou et al., 2014).

Arsenic (As)

The results disclosed that there was no significant variation (F-value = 2.80; p-value = 0.05) in the mean levels of arsenic among Tai (0.001), Obio/Akpor (0.004), Phalga (0.0002), Oyibo (0.0006) and Eleme (0.0002) local government areas during dry season. Also, there was no significant difference (F-value = n/a; p-value > 0.05) in the mean levels of arsenic among Tai (0.001), Obio/Akpor (0.001), Phalga (0.001), Oyibo (0.001) and Eleme (0.001) local government areas during rainy season.

The determined values of As in the study from all the examined location were lesser than the SON, WHO, USEPA and EU requirement values for drinkable water. The values of As gotten from the examined tap water from the different locations were lower than the values of Gebrekidan and Samuel (2016) in tap water from built-up regions of Tigray, Northern Ethiopia and also lesser than the quantity of Edori and Kpee, 2016) in tap water close to abattoir.

Scientific researchers and professionals in the public health sector are alarmed on the chronic and acute effects associated with low level intake/contact of arsenic by humans. Of utmost concern are the babies and teenagers exposed to arsenic laden water and contaminated foods in their developmental stages (NRC, 2012). The use of adulterated water for drinking, processing of food and in irrigation are routes of As exposure. Others include industrial practices, eating contaminated food and tobacco smoking (Chung et al., 2014). Long-standing contact with inorganic arsenic, principally from oral water and food intake, can lead to lingering harm. Skin abrasions and skin malignancy are the most commonly noticed distinguishing effects (Järup, 2003).

The inorganic form of As is an established cancer-causing agent and is the furthermost noteworthy compound poison in accessible water worldwide. Organic As forms also found in nature. Non-carbon based arsenic complexes especially in water are very poisonous while carbon based arsenics in seafood are less detrimental to well-being (Kumar et al., 2020). Inappropriate disposal of refuse containing arsenic and its compounds, the use of pesticides containing arsenic, natural content of arsenic in soil are sources of As impurity of groundwater. Continuous use of drinking water containing arsenic even at a very low concentration can lead to skin, lungs, bladder and kidney cancer. Other effects include skin thickening and pigmentation (Matta & Gjyli, 2016).

Amplified hazards of lung and bladder distortion and skin alterations were stated in persons consuming arsenic through water intake at levels of 50 μg/litre, or lesser (Mahurpawar, 2015). Soluble mineral arsenic can cause instantaneous deadly effects. Assimilation of great quantities can possibly cause abdominal indications like austere spewing, turmoil of the blood movement, nervous system impairment, and ultimately death. While non-deadly intake of large dosages may possibly diminish blood cell manufacture, breakdown red blood cells in circulation, hypertrophy and hyperplasia of liver cells, pigmentation of the skin, cause prickling and injury of numbness in the appendages, and cause intellect impairment (Mahurpawar, 2015). Bases of As contact are job-related or thru unclean food and water. It is disreputably recognized as the king of toxins and toxin of king (Gupta et al., 2017).

Iron (Fe)

The results disclosed that there was no significant variation (F-value = 0.00; p-value > 0.05) in the mean levels of iron among Tai (0.00), Obio/Akpor (0.00), Phalga (0.00), Oyibo (0.00) and Eleme (0.00) local government areas during dry season. Also, there was no significant variation (F-value =0.0; p-value > 0.05) in the mean levels of cadmium among Tai (0.00), Obio/Akpor (0.00), Phalga (0.00), Oyibo (0.00) and Eleme (0.00) local government areas during rainy season.

The determined values of Fe in the study from all the examined location were lesser than the SON, WHO, USEPA and EU requirement values for accessible water. The values Fe obtained from the different tap water in flooded areas from the examined location were lower than values of other authors elsewhere (Bozkurt et al., 2016; Masok et al., 2017; Liu et al., 2023).

Iron is twenty-five percent by mass in the earth's layer. It is always present in water predominantly in ferrous or ferric state (Ghulman et al., 2008). It is an indispensable and non-conventional trace metal found in reasonable quantity in portable water for the reason of its large quantity in the earth's crust. Frequently, Fe presence in groundwater occur as ferric hydroxide, in amount not up to 500 µg/L (Oyeku and Eludoyin, 2010).

The incidence of Fe in freshwater in groundwater come from divergent sources. They majorly come from natural iron originating from rocks and soils from nearby watershed. The obtainability of Fe from these sources is as a result of soil structure, geologic developments or materialization, temperature of the environment, rainfall, hydrology and deposition (Herut et al., 2001). Fe is an imperative constituent of hemoglobin; the constituent that give the red colour to the blood and is accountable for the transference of oxygen to the numerous tissues and organs of the body (Wei et al., 2005).

When Fe is consumed or contacted through the skin, it may lead to several ailment conditions namely: conjunctivitis, choroiditis, and retinitis. Protracted inhalation of too much concentrations of Fe fumes and dust of its oxide can consequential in the development of a disease condition of benign pneumoconiosis, otherwise called siderosis (Rajappa et al., 2010; Bhaskar et al., 2010), which is observable as an x-ray change. However, circumstances of somatic lung damage and breakdown have not been linked with siderosis. Intake of extraordinary levels or concentrations of the oxides of iron intensifies the possibility of growth of lung cancer specifically in employees open to pulmonic poisons (Rind et al., 2013). However, Fe deficiency is associated with anaemia in humans. The normal daily consumption of Fe necessary or recommended for males and females are 7 and 11 mg respectively (Banjari et al., 2015).

Table 1: Heavy metal levels (mg/L) in pipe borne water in dry season in selected Local Government Areas in Rivers State

Heavy metals	Tai	Obio/Akpor	Phalga	Oyibo	Eleme	F-value	p-value	Remark
Cd	0.0008	0.0006	0.0006	0.0004	0.0004	0.5	0.74	NS
Pb	0.001	0.004	0.002	0.0004	0.0002	0.65	0.63	NS
As	0.001	0.004	0.0002	0.0006	0.0002	2.80	0.05	NS
Fe	ND	ND	ND	0.80	ND	ND	>0.05	NS

Table 2: Heavy metal levels (mg/L) in pipe borne water in rainy season in selected Local Government Areas in Rivers State

Heavy metals	Tai	Obio/Akpor	Phalga	Oyibo	Eleme	F-value	p-value	Remark
Cd	0.001	0.001	0.001	0.001	0.001	n/a	>0.05	NS
Pb	0.001	0.001	0.001	0.001	0.001	n/a	>0.05	NS
As	0.001	0.001	0.001	0.001	0.001	n/a	>0.05	NS
Fe	ND	ND	ND	ND	ND		>0.05	NS

Table 3. Drinking water contaminants and maximum allowable limit set by different National and International Organizations.

Standards	Heavy metals (mg/L)			
	Cd	Pb	As	Fe
SON	0.003	0.01	0.01	0.3
USEPA	0.005	0.015	0.01	0.3
EU	0.005	0.01	0.01	0.2
WHO (2011)	0.003	0.01	0.01	0.3

Conclusion

This study assessed the concentrations of heavy metals in tap water from selected flooded areas in parts of Rivers State, Nigeria. The metals studied were Cd, Pb, As and Fe. The values of the different heavy metals in both dry and rainy seasons were lower than regulated standard, which implies that the heavy metals were within acceptable limits. Based on the findings of this work, it is therefore recommended that, concerted and continuous efforts should be in use to sustain the present trend and possible environmental safety methods be put in place by government and relevant bodies.

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