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# Determination of heavy metals concentration in water and sediment of river donga, Taraba state

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**Abstract**
This research was carried out to ascertain the heavy metals concentrations in water and sediments from River Donga upstream and downstream was investigated for a period of three months (October to December). The Result showed heavy metals concentrations were higher in sediments compare to water during the study period while downstream values were generally higher compare to upstream. Result for mean concentration of heavy metals variations in water and sediment varied significant ($p$>0.05) based on the two sampling locations upstream and downstream. The heavy metals concentration in water and sediments was examined using atomic absorption spectrophotometer (AAS) Bulk scientific Model 210VGP. Concentrations ranking profile was found to be Zn >Ni>Pb >Cr>Cd. The maximum mean concentration of Zn recorded in the sediment was 0.700 mg/kg while the lowest value of 0.029 mg/kg was recorded for Pb at the two locations while for water value (0.200 mg/l) were observed for Zn, Ni, and Cr in the months of October November and December respectively. The lowest value of 0.014 mg/1 at both locations was recorded for Cr. Data for Cr, Ni, Pb. Pb were generally low throughout the study period. Zn concentrations in water at the sampled locations (upstream and downstream) throughout the study periods showed no significant difference ($p$>0.05). However, Cd, Cr, Pb and Ni show variations ($p$<0.05) at the sampled locations. The highest mean concentration recorded for Zn (0.300 mg/l) in water was observed in the upstream in November while the lowest value (0.011 mg/l) was recorded for Cd in December, downstream. However, all values in the water and sediments were below the WHO and FAO safe recommended limit for portable drinking water.

**Keywords:** Heavy metals, water, sediments and physico-chemical parameters

## 1. Introduction

Rivers are used for a variety of purposes such as drinking, washing, bathing, recreation as well as numerous other varied industrial applications, the wholesomeness 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 waste and plethora of human activities, which adversely affects their physicochemical properties including microbiological quality content. It is a serious growing problem. The increasing amount of industrial and municipal waste that are being discharged into rivers has led to various deteriorating effects on aquatic organism which accumulate pollutants directly from contaminated water and indirectly via food chain. Human feed on these aquatic animals hence the accumulated pollutants are transferred into the body system causing diseases and infections (Olatunji *et al*., 2011) [26].

A river system can be severally contaminated by heavy metals as a result of domestic, industrial mining and related agricultural influence (Yight and Attindag, 2002). 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 extend of the contamination [14].

Heavy metals are those metallic elements that have a relatively high density compared to water with the assumption that heaviness and toxicity are inter-related, heavy metals also include metalloids, such as arsenic, that are able to induce toxicity at low level of exposure (Diffus, 2002). In recent years, there has been an increasing ecological and global public health concern associated with environmental contamination by these metals.

Also, human exposure has risen dramatically as a result of an exponential increase of their use in several industrial, agricultural, domestic and technological applications. Reported sources of heavy metals in the environment include geogenic, industrial, agricultural, pharmaceutical, domestic effluents, and atmospheric sources. Environmental pollution is very prominent in point source areas such as mining, foundries and smelters, and other metal-based industrial operations (Stoffella *et al*., 2005) [27].

Although heavy metals are naturally occurring elements that are found throughout the earth's crust, most environmental contamination and human exposure result from anthropogenic activities such as mining and smelting operations, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds. (Stoffella *et al*. 2005) [27].

Environmental contamination can also occur through metal corrosion, atmospheric deposition, soil erosion of metal ions and leaching of heavy metals, sediment re-suspension and metal eva poration from water resources to soil and ground water. Natural phenomena such as weathering and volcanic eruptions have also been reported to significantly contribute to heavy metal pollution. Industrial sources include metal processing in refineries, coal burning in power plants, petroleum combustion, nuclear power stations and high tension lines, plastics, textiles, microelectronics, wood preservation and paper processing plants (Arruti *et al*., 2010).

It has been reported that metals such as cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se) and zinc (Zn) are essential nutrients that are required for various biochemical and physiological functions. Inadequate supply of these micro-nutrients results in a variety of deficiency diseases or syndromes (Ikponmwen *et. al*., 2020) [15].

## 2. Materials and Methods

### 2.1 Study Area

This study was carried out at river Donga, Taraba state, Nigeria. River Donga is located at the southern part of Taraba state. It is found within Latitude: 7° 42' 59.99" N

Longitude: 10° 02' 60.00"E. It is about 350m below sea level. and about 217km from the state capital Jalingo having common border with kurmi LGA in the east, Wukari LGA in the south, Gassol to the north, Bali LGA in the northeast, It has a land mass of about 3,121 km$^2$ and with the population of about that is from 2006-2016 is 177, 900, human population, and there are four major languages there are Chamba, Jukum, Ichen and Gibawa that are found in Donga LGA of Taraba State. The occupation of the people of Donga LGA are more of farming activities in the local government area and are few are into fishing The river receives effluent discharges from rice mill, fertilizer runoff, pesticides, herbicides, diesel, and domestic waste from people living close to the river. These are discharged into the river through drains, surface runoff and water ways during rainy season and through seepage. The people also used the river for fishing and domestic purposes.

The study area experiences a tropical climate condition with distinct rainy (March-October) and dry (November-April) season**.** The annual rainfall in this area is between 1200-1800mm.this is high rainfall coupled with high temperature of 28$^0$ 35 °C is typical of the Guinea Savanna vegetation type.

### 2.2 Experimental Procedure

The experiment was carried out in four phases and an interval of one kilometer each between station one and two was considered

**Phase 1:** Collection of water and sediment samples from the sample sites.

**Phase 2:** Laboratory experiment was carried out in central laboratory Federal University Wukari. These include: digestion of water and sediment.

**Phase 3**: Determination of physicochemical parameters. The physicochemical parameters to be determined include:

i. Water temperature.
ii. Water pH.
iii. Total dissolved solid
iv. Electrical conductivity
v. Dissolved oxygen

**Phase 4**: statistical analysis of the data generated

### 2.3 Collection of Samples

#### 2.3.1 Water

Water samples was collected from a determined point of 15-3°Cm and acidified to pH 1.5 with nitric acid after collection [3]. They were be sealed and stored in plastic containers previously washed and rinsed with distilled water. The sample was collected monthly for a period of three months (From October to December 2021). All samples were transported to the laboratory and stored in refrigerator (at-10 °C).

#### 2.3.2 Sediment

Samples for Sediment were collected from the two sample locations by means of bottom grap sampler. They were placed in plastic bags earlier drenched in nitric acid and cleaned in distilled water. Sediment samples will be air- dried at a temperature of 60 °C in a moisture extraction oven to constant weight. They will be stored in labeled packs prior to digestion and analysis.

### 2.4 Digestion of Samples

#### 2.4.1 Water

The frozen water samples were allowed to defrost at room temperature (27 °C) and digested using pre-concentrated Nitric acid method (Parker, 1972) [28]. Blanks will be prepared with acids.

#### 2.4.2 Sediment

The oven-dried sediment samples were filtered through a 200m mesh size screen. The samples were weighed and 1g of each sample was placed into a 250ml flask and digested with hydrochloric acid (10ml). The mixture was heated until a milky precipitate appears indicating complete digestion. The precipitate were then allowed to cool and made up to mark with distilled water. Blanks were prepared using the same quantity of hydrochloric acid.

### 2.5 Analysis of Heavy Metals

The following heavy metals in water and sediment was analyzed; Lead (Pb), Copper (Cu), Chromium (Cr) at Central laboratory and biological Laboratory, Federal university Wukari, Heavy metals analyses was carried out using Atomic Absorption Spectrophotometer (AAS) Buck scientific machine, Model 210VGP.

### 2.6 Experimental Design

The experiment was designed as a factorial experiment in complete randomized design (CRD), involving 2 (location) × 2 (Samples) × 5 (metals) replicated thrice.

### 2.7 Data Analysis
The presentation of Data was achieved by using means and standard deviations. Means were subjected to one-way analysis of variance (ANOVA) using 9.0 statistical package for scientist and social sciences (SPSE) (2012) to determine significant differences at 5% level of probability. Significant means will be subjected to Duncan Multiple Range Test (DMRT) (Duncan D.B 1955) [29].

## 3. Results
### 3.1 The Result on Heavy metals Variation in water and Sediment from River Donga
The results for determination of heavy metals concentrations in water and sediments at two locations upstream and downstream of River Donga are presented in Table 1 to 4 below. The Results showed that heavy metals concentrations were higher in sediments compare to water. The mean concentration of heavy metals variations in sediment and water from the two sampling locations (Upstream and downstream) are shown in Table 1. The result showed that more of metals are concentrated in the sediment compared to water. The highest mean concentration (0.575 mg/kg) recorded for Zn was observed in the sediment in December while the lowest value 0.029 mg/kg was recorded for Lead (Pb) in October. The highest value (0.200 mg/l) recorded in water was observed for Nickel (Ni) while the lowest value (0.014 mg/l) was recorded for Chromium (Cr) in December.

### 3.2 The Result for Mean Heavy metals variations of River Donga water between locations with time
The results of the mean heavy metals variation of River Donga water between locations with time is made known in Table 2. The result showed that Zinc (Zn) and Nickel (Ni) values were generally higher throughout the study period. Value of Ni (0.250 mg/l) upstream in October and November while Zn (0.300 mg/l) in November were higher compare to downstream values in other months. Lead (Pb) values (0.019 mg/l, 0.022 mg/l and 0.025mg/l) were generally lower through the study followed by Chromium (Cr) value (0.017 mg/l).

**Table 1:** Result on Mean Variation of Heavy metals in water and sediment during the study period

| Concentration (mg/kg) Month | | | | |
|---|---|---|---|---|
| **Heavy Metals** | **Sampling Points** | **Oct** | **Nov** | **Dec** |
| Pb | Sediment | $0.029^b \pm 0.027$ | $0.039^c \pm 0.008$ | $0.056^c \pm 0.028$ |
| | Water | $0.015^b \pm 0.005$ | $0.046^c \pm 0.041$ | $0.049^c \pm 0.050$ |
| Cd | Sediment | $0.015^e \pm 0.006$ | $0.009^e \pm 0.005$ | $0.006^e \pm 0.003$ |
| | Water | $0.020^a \pm 0.011$ | $0.008^e \pm 0.005$ | $0.010^e \pm 0.003$ |
| Cr | Sediment | $0.016^d \pm 0.005$ | $0.017^d \pm 0.013$ | $0.019^d \pm 0.007$ |
| | Water | $0.020^a \pm 0.004$ | $0.019^d \pm 0.008$ | $0.014^d \pm 0.012$ |
| Zn | Sediment | $0.400^a \pm 0.258$ | $0.700^a \pm 0.141$ | $0.575^a \pm 0.150$ |
| | Water | 0.10°C ± 0.000 | $0.200^a \pm 0.200$ | $0.100^b \pm 0.000$ |
| Ni | Sediment | 0.25°C ± 0.129 | $0.300^b \pm 0.082$ | $2.225^b \pm 0.126$ |
| | Water | $0.200^a \pm 0.141$ | $0.150^b \pm 0.058$ | $0.126^a \pm 0.189$ |

Results are expressed as Mean ± Standard deviation (SD). Means having the same letters in a row are not significantly different ($p > 0.05$).

**Table 2:** Mean Heavy metals variations of River Donga water between location with time

| Concentration (mg/l) Month | | | | |
|---|---|---|---|---|
| **Heavy metal** | **Sampling Location** | **Oct** | **Nov** | **Dec** |
| Pb | Upstream | $0.019 \pm 0.005^a$ | $0.022 \pm 0.026^a$ | $0.025 \pm 0.030^a$ |
| | Downstream | $0.074 \pm 0.092^a$ | $0.071 \pm 0.044^a$ | $0.074 \pm 0.066^a$ |
| Cd | Upstream | $0.025 \pm 0.013^a$ | $0.005 \pm 0.005^a$ | $0.012 \pm 0.004^a$ |
| | Downstream | $0.015 \pm 0.008^a$ | $0.012 \pm 0.001^a$ | $0.011 \pm 0.005^a$ |
| Cr | Upstream | $0.017 \pm 0.001^a$ | $0.023 \pm 0.000^a$ | $0.005 \pm 0.003^a$ |
| | Downstream | $0.024 \pm 0.001^a$ | $0.114 \pm 0.151^b$ | $0.022 \pm 0.011^a$ |
| Zn | Upstream | $0.100 \pm 0.000^a$ | $0.300 \pm 0.283^a$ | $0.100 \pm 0.000^a$ |
| | Downstream | $0.100 \pm 0.000^a$ | $0.100 \pm 0.000^b$ | $0.100 \pm 0.000^a$ |
| Ni | Upstream | $0.250 \pm 0.212^a$ | $0.100 \pm 0.000^a$ | $0.200 \pm 0.282^a$ |
| | Downstream | $0.150 \pm 0.071^a$ | $0.200 \pm 0.000^a$ | $0.250 \pm 0.212^a$ |

Results are expressed as Mean ± Standard deviation (SD). Means having the same letters in a row are not significantly different ($p > 0.05$).

### 3.3 The Result on Heavy metals Concentrations in Sediment from upstream and Downstream of River Donga
Results of mean variations of heavy metal in sediment between locations during the study period is presented in Table 3. The higher value (0.800 mg/kg, 0.700 mg/kg and 0.400 mg/kg) were recorded for Zinc (Zn) upstream in November, December and October during the study period while lower values (0.012,0.013,.0.005 mg/kg)were recorded in the months of October, November and December for Cadmium. Lead values were also lower with the lowest been 0.009 mg/kg upstream.

### 3.4 The Result on Variation of Selected Physico-chemical parameters in River Donga between locations with time
The results of some important physico-chemical parameters measured through the duration of study from River Donga are shown in Table 4. Total dissolve solids recorded the highest values (200 mg/l) compare to other parameters.

**Table 3:** Means variations of Heavy metals in Sediment between locations during the study period with time

| Heavy Metals | Concentration (mg/kg) Month | | | |
|---|---|---|---|---|
| | Sampling Points | Oct | Nov | Dec |
| Pb | Upstream | $0.009^f \pm 0.008$ | $0.077^d \pm 0.017$ | $0.034^e \pm 0.008$ |
| | Downstream | $0.050^e \pm 0.022$ | $0.034^d \pm 0.017$ | $0.043^c \pm 0.004$ |
| Cd | Upstream | $0.012^e \pm 0.004$ | $0.013^e \pm 0.005$ | $0.005^f \pm 0.003$ |
| | Downstream | $0.019^c \pm 0.006$ | $0.006^a \pm 0.001$ | $0.008^e \pm 0.014$ |
| Cr | Upstream | $0.017^d \pm 0.002$ | $0.026^c \pm 0.011$ | $0.021^d \pm 0.011$ |
| | Downstream | $0.016^f \pm 0.008$ | $0.009^e \pm 0.010$ | $0.017^d \pm 0.006$ |
| Zn | Upstream | $0.400^a \pm 0.424$ | $0.800^a \pm 0.141$ | $0.700^a \pm 0.000$ |
| | Downstream | $0.400^a \pm 0.142$ | $0.600^a \pm 0.000$ | $0.450^a \pm 0.071$ |
| Ni | Upstream | $0.250^b \pm 0.071$ | $0.300^b \pm 0.000$ | $0.150^b \pm 0.071$ |
| | Downstream | $0.250^b \pm 0.212$ | $0.300^b \pm 0.141$ | $0.300^b \pm 0.141$ |

Results are expressed as Mean ± Standard deviation (SD). Means having the same letters in a row are not significantly different ($p < 0.05$).

**Table 4:** Mean Variation of Selected Physico-chemical parameters in River Donga between location with time

| Physico-chemical parameters | | Month | | |
|---|---|---|---|---|
| | Sampling Points | Oct | Nov | Dec |
| Water temperature (°C) | Downstream | $30.75^b \pm 0.87$ | 32.1°C ± 0.05 | $30.85^b \pm 1.16$ |
| | Upstream | 31.3°C± 0.12 | 31.1°C ± 0.05 | $30.15^b \pm 1.54$ |
| D.O (mg/l) | Downstream | $8.35^e \pm 0.62$ | $6.55^e \pm 0.19$ | $8.15^d \pm 0.75$ |
| | Upstream | $6.80^e \pm 0.15$ | $6.60^e \pm 0.00$ | $7.55^d \pm 0.88$ |
| pH | Downstream | $10.70^d \pm 0.09$ | $8.90^d \pm 0.03$ | $4.81^e \pm 0.05$ |
| | Upstream | $9.68^d \pm 0.03$ | $9.46^d \pm 0.03$ | $5.13^e \pm 0.11$ |
| Electrical conductivity(µs/ppm) Total dissolve solid µS/m | Downstream | 21.9°C ± 0.00 | $22.80^b \pm 0.05$ | 22.8°C ± 0.02 |
| | Upstream | $21.80^b \pm 0.00$ | $20.55^b \pm 0.00$ | $25.6^c \pm 0.05$ |
| | Downstream | $190^a \pm 0.00$ | $200^a \pm 0.01$ | $180^a \pm 0.09$ |
| | Upstream | $200^a \pm 0.00$ | $200^a \pm 0.01$ | $200^a \pm 0.15$ |

Results are expressed as Mean ± Standard deviation (SD). Means having the same letters in a row are not significantly different ($p < 0.05$).

## 4. Discussion, conclusion and recommendation

### 4.1 Discussion

#### 4.1.1 Heavy metals Variation in water and Sediment from River Donga

Heavy metals concentrations in water and sediments from River Donga shows heavy metals concentration were higher in sediments compare to water during the study period. The mean concentration of heavy metals variations in water and sediment varied based on the two sampling locations upstream and downstream. The result showed that more of the metals are concentrated in the sediment compared to water, the maximum mean concentration recorded for Zn was observed in the sediment in December while the least value was noted for Lead (Pb) in October. The maximum value recorded for water was observed in Ni while the least value was recorded for Chromium (Cr) in December. These variation in values may be attributed to the the large volume of effluents discharge from domestic waste and runoff from pesticide, fertilizer and diesel products which has accumulated overtime [6]. Heavy metals concentration in this study were generally lower Cr, Pb, Cd were generally low during the study in both water and sediment. This finding similar to report by [21] for Ovia River who reported low levels of heavy metals in water compare to sediment of Ovia river except for Zn and Cu that had higher levels in the water, that this may be due to dilution effect caused by rain during rainy period. Values obtained for Pb were lower in water compare to sediment during the study period The values for Pb was generally lower than the limit (0.05 mg/l) recommended by WHO (2008) for portable drinking water however it was lower than (35.80 mg/kg) recommended by FAO/WHO (2004) for sediments in fresh water. This may due high level of sedimentation occuring downstream compare to upstream. This is in agreement with Maitera ON *et al.*, (2011) [30] who reported that there is high concentration of heavy metals in sediments when compare to water. Higher concentration of heavy metals in sediments may be due to sediments acting as sink to heavy metals and inability of the metals to dissolve in water thus got deposited in the sediment (Edward *et. al.*, 2016) [8].

#### 4.1.2 Heavy metals Concentrations upstream and Downstream of River Donga Water

The mean heavy metal concentration in River Donga showed given pattern based on location during the study period. Generally results showed that more of the metals were concentrated downstream than upstream. Mean metals value recorded downstream were higher compare to most values gotten upstream. This finding corroborated report by [18] who reported higher heavy metals downstream compare to upstream. Values obtained for Pb were generally lower during the study period than the limit (0.05 mg/l) recommended by WHO (2008) for portable drinking water and the (2.0 mg/kg) recommended by FAO/WHO (2004) for food and food products.

#### 4.1.3 Physico-chemical parameters in River Donga waters.

Water temperature were within the optimum range (23-32 mg/l) ideal for fish survival and growth throughout the study period as recommended by federal ministry for environment [12]. Environmental temperature has been found to influence breeding and reproductive behavior in aquatic animals thus it plays a major role overtime. [19]. In Nigeria, water temperature is usually high as a result of during the dry periods [20], which harpers the spawning of fish. Report on the range for water temperature required for spawning vary between 21 °C and 30 °C. Spawning activity can decrease rapidly at temperatures below 21 °C or above 30 °C, the water must be 24 °C-30 °C for successful hatching [9]. Temperature is also known to have strong influence on heavy metal dilution, enzyme reaction, growth efficiency, reproduction and immune response in fish [24].

The dissolve oxygen range throughout the study period was slightly higher than the optimum range (6-8 mg/l) recommended by the federal ministry for environment [12] best for fish survival. The best range of dissolved oxygen for growth and reproduction is from 5 mg/l-8 mg/l [25]. Generally, when an organism is subjected to chemical, physical, or biological (i.e. pathogen infection) stress, sudden shortage of dissolve oxygen causes abnormal oxidative reactions in the aerobic metabolic pathways, resulting in the formation of excessive amounts of singlet oxygen and free radicals [22, 25].

Water pH was also within safe range recommended by [12] throughout the study period. Total dissolve solid values was within safe limit throughout the study period. High values of total dissolved solids tend to affect heavy metal availability since this will also affect the level of sedimentation in the river water. High TDS values have aquatic plant growth, which also causes high turbidity in river water [19].

### 4.2 Conclusion

The results obtained from this study confirmed the occurrence and intensities of heavy metals concentration (Zn, Ni, Pb, Cd, Cr) in water and sediment of River Donga at Taraba State. The levels of Zn, Ni, Cd, Cr Pb, in the water and sediment studied were below the WHO and FAO recommended limits in quality drinking water and sediment. However, there is need for continuous monitoring of River Donga waters.

### 4.3 Recommendation

In other to avoid serious environmental risks, there is need to establish effective water pollution control measures and management of River Donga water.

The following recommendations are necessary and would need to be implemented:

i. Continuous monitoring of the pollution levels of the river to provide adequate information necessary for its effective management.
ii. Provision of portable drinking water supply in form of pipe borne water and borehole to fishing communities around River Donga, and adjourning towns along the river bank.
iii. Promulgation of law where necessary and enforcement of these and other existing regulation regarding discharge of untreated waste into the River.
iv. Practices that increases the heavy metal load such as indiscriminate dumping of refuse, agriculture fertilizer effluents as well as laundry and bathing activities along the river course should be discouraged.
v. Proper discharge of wastes and sewage should be provided by government.
vi. The need for regular monitoring of inland water body should be intensified and culprit apprehended.

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