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*Full Length Research Paper*

# Metal concentrations in sediments and water from Rivers Doma, Farinruwa and Mada in Nasarawa State, Nigeria

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**The Rivers Doma, Farinruwa and Mada are important rivers in Nasarawa State, Nigeria especially with regard to domestic use, irrigation and aquatic food. Levels of sodium, potassium, nickel, copper, magnesium, iron, calcium, zinc, lead, cadmium, arsenic, selenium, chromium and manganese were determined in samples of sediment and water collected from different points of the three rivers at two distinct seasons (dry and wet) using atomic absorption spectrophotometer. The results showed that calcium had the highest concentration in sediment and water samples for both seasons. It was found that the cadmium, arsenic and selenium were completely not within the detection limit of AAS for all the water samples for dry and wet seasons. The results further revealed that Ni, Fe, Pb, and Mn concentrations in all the water samples are above the deleterious level based on the standard limits set by World Health Organization (WHO) for drinking water. However, source protection is proposed for these bodies of water for the benefit of mankind, because they were not fit for human consumption**.

**Key words:** River-water, sediments, metal, AAS.

## INTRODUCTION

It is a well known fact that adequate supply of fresh and clean drinking water is a basic need for all human beings on earth; yet it has been observed that millions of people are deprived of this, particularly in the developing countries, including Nigeria. This is due not only to over exploitation and poor management of fresh water but also due to their ecological degradation by man's activities in this part of the country (Okuo et al., 2007).

Industrial growth, urbanization and the increasing use of synthetic organic substances have serious and adverse impacts on freshwater bodies due to the introduction of various pollutants such as organic compounds, heavy metals, agricultural waste, etc. (Kakulu and Osibanjo, 1988). Metals are introduced into aquatic systems as result of the weathering of rocks and soils, for example, volcanic eruptions and also from several human and industrial materials that contain metals contaminants (Marr and Creaser, 1983; Adeyeye, 1993; Gutenmann et al., 1988). The increased use of metal containing fertilizers due to the agricultural revolution could lead to pollutants in fresh water reservoirs due to water run-off (Aremu and Inajoh, 2007). Vehicle emissions, and tire and engine wear contribute sizeable concentration of all metals, particularly zinc and copper. Thus, significant correlations are found between traffic volumes and metal concentrations (Ademoroti, 1996; Aremu et al., 2006). Heavy metals are commonly found in natural waters. Though some are essential to living organisms, yet they may become highly toxic when present in high concentration. Some of these heavy metals, for examples, lead, zinc, manganese, iron, nickel and copper occur in nature in ore deposits. They are released through leaching and weathering into the rivers. Therefore areas characterized by the presence of metal bearing formations and mining operations are expected to have elevated levels of metals in water and sediments (Foster and Wiltman, 1983; Preston and Chester, 1996). Sediments in the aquatic environments form the major

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repository of heavy metals, holding > 90% of the total amount (Preston and Chester, 1996).

Potable water supply to communities in Nasarawa State is the responsibilities of the government which in most cases has been characterized by low productivity, small coverage and inefficient service delivery. Doma, Wamba and part of Akwanga local government areas are one of the areas that do not enjoy potable water supply. Most rural dwellers therefore depend on various available water sources. The qualities of these sources are generally not guaranteed and cases abound where health problems have risen as a result of consumers drinking from such sources. Thus for people in Doma, Wamba and part of Akwanga local government areas of Nasarawa State, Nigeria to meet their daily water needs and households' requirement, they source water from a few privately and government owned boreholes and wells while majority depend largely on Rivers Doma, Farinruwa and Mada located in Doma, Wamba and Akwanga local government areas, respectively.

This work aims at investigating the pollution levels of Na, K, Ni, Cu, Mg, Fe, Ca, Zn, Pb, Cd, As Se, Cr and Mn in the sediments and water from the three rivers which are the main sources of potable water for the inhabitants in these areas.

## MATERIALS AND METHODS

### Study area

Nasarawa State is one of 36 States in the Federal Republic of Nigeria. It is located in north-central geopolitical zone of Nigeria otherwise known as the middle belt region. The State is made up of thirteen (13) local government areas. Rivers Doma, Farinruwa and Mada are found in Doma, Wamba and Akwanga local government areas, respectively. Their latitudes are 08° 66" – 08° 72", 08° 52 – 08° 58" and 08° 49 – 08° 52" while their longitudes are 07° 64" – 07° 69", 07° 53" – 07° 57" and 07° 51" – 07° 56", respectively. These local government areas share boundaries with Benue, Plateau and Kaduna States in Nigeria (Figure 1).

The physical features of the area are largely mountainous, most of which are rocky and of undulating highlands of average height. It has a typical climate of the tropical zone because of its location. Its climate is quite pleasant with a maximum temperature of 95°F and a minimum of 50°F. Rainfall varies 131.73 cm in some places to 145 cm in others (Obaje et al., 2005). Mineral resources such as marble deposits, granite rocks, baryte and mica are found in some areas. The climate is characterized by two distinct seasons, dry and wet. The dry season spans from October to March while the raining season is from April to September. The months of December, January and February are cold due to harmattern wind blowing across the local government areas from the north-east of Nigeria. The sediments are generally comprised of sandstones, silt stones and forest soils which are rich in humus and very good for crop production. More than 80% of the inhabitants are predominantly farmers while few engage in fishing business.

### Samples collection

Water samples were collected between May to July, 2009 and November, 2009 to February, 2010 for wet and dry seasons, respectively. Representative water samples were taken just below the water surface at three different locations of each river using one litre acid leached polythene bottle. The water samples were stored in a deep freezer at –18°C prior to analysis. A diver was used to take soil sediment samples from the surface down to a depth of about 15 cm at locations where water samples were taken, stored in a polythene bag which had been washed and leached accordingly (Aremu et al., 2008) and kept in deep freezer prior to analysis.

### Samples treatment

A known volume (5 $cm^3$) of concentrated hydrochloric acid was added to 250 $cm^3$ of water sample and evaporated to 25 $cm^3$. The concentrate was transferred to 50 $cm^3$ standard flask and diluted to the mark with distilled deionized water (Aremu et al., 2006). The soil sample was air-dried, and then sieved using 200 mm mesh. Five gramme of the soil sample was weighed into 150 $cm^3$ conical flask, digested using 150 $cm^3$ nitric acid, 2 $cm^3$ perchloric acid and placed on a hot plate for 3 h (Adeyeye, 1993). On cooling, the digest was filtered into 100 $cm^3$ volumetric flask and make up to mark with distilled water.

### Mineral analysis

The elemental analysis (except Na and K) was done in the water samples using Perkins Elmer and Oak Brown (UK) atomic absorption spectrophotometer. The instrument settings and operational conditions were done in accordance with the manufacturer's specifications. Na and K were determined by using a flame photometer (Model 405, Corning, UK).

All the chemicals used were of analytical grade and obtained from British Drug Honks (BDH, London).

### Statistical analysis

All the data generated were analyzed statistically (Steel and Torrie, 1960). Parameters evaluated were grand means, standard deviation and coefficient of variation. All the determinations were in triplicate.

## RESULTS AND DISCUSSION

The result of trace metals in sediments and ambient water of both dry and wet seasons in Doma River is displayed in Tables 1A and 1B. The highest concentrated mineral in sediment and water samples for both seasons was Ca while the least was Cd (dry season) and Se (wet season). The following metals were not within the detection limit Cd, As, Se and Cr in water (dry season); Ni, Zn, Cd, As, Se and Mn in water and Cd in sediments (wet season). When compared, the level of trace metals in the water and sediment samples, the highest variability was found in Mn (90.48%) and Pb (88.64%) for dry and wet seasons, respectively while the least were Mg (33.05%) and Ca (40.06%) (Tables 1A and 1B). The orders of variation were found to be Mn > Ni > Zn = Pb > Fe > Cu > K > Na > Ca > Mg (dry season) and Pb > Fe > Cr > Na > Cr > K > Mg > Ca (wet season). The results of metal analysis in Farinruwa River water sample is

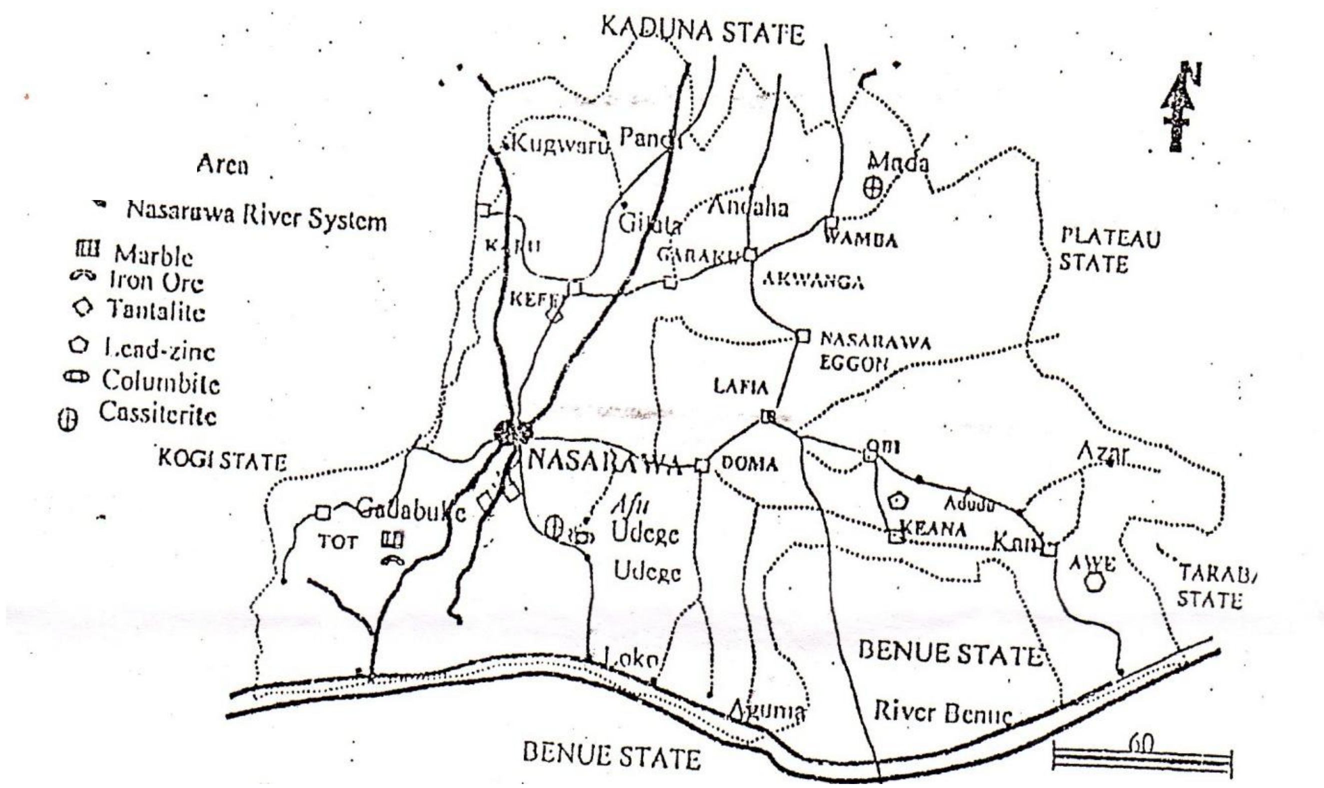


**Figure 1.** Map of Nasarawa State showing the study area.

**Table 1a.** Metals concentration (ppm)[a] of sediments and ambient water in River Doma dry season.

| Mineral | Sediments | Water | Mean | SD | CV% |
|---|---|---|---|---|---|
| Na | 5.64 ± 2.50 | 2.82 ± 1.20 | 4.23 | 1.41 | 33.33 |
| K | 3.15 ± 0.50 | 2.01 ± 1.05 | 3.46 | 1.45 | 41.91 |
| Ni | 3.15 ± 1.00 | 0.18 ± 1.20 | 1.67 | 1.48 | 88.62 |
| Cu | 2.36 ± 1.50 | 0.49 ± 1.15 | 1.43 | 0.94 | 65.75 |
| Mg | 17.19 ± 5.05 | 8.45 ± 2.10 | 12.92 | 4.27 | 33.05 |
| Fe | 10.88 ± 1.50 | 1.19 ± 1.50 | 6.04 | 4.85 | 80.3 |
| Ca | 22.66 ± 2.50 | 11.34 ± 1.00 | 17 | 5.66 | 33.29 |
| Zn | 2.88 ± 1.01 | 0.31 ± 0.01 | 1.6 | 1.29 | 80.63 |
| Pb | 1.36 ± 0.10 | 0.15 ± 0.15 | 0.76 | 0.61 | 80.63 |
| Cd | 0.21 ± 1.02 | ND | nd | nd | nd |
| As | 2.28 ± 1.50 | ND | nd | nd | nd |
| Se | 1.14 ± 1.30 | ND | nd | nd | nd |
| Cr | 2.10 ± 0.00 | ND | nd | nd | nd |
| Mn | 2.40 ± 0.10 | 0.12 ± 2.10 | 1.26 | 1.14 | 90.48 |

ND = not detected; SD = standard deviation; CV% = coefficient of variation percent; nd = not determined; [a]Values are mean ± standard deviation of triplicate determinations

presented in Table 2. Cd, As and Se in water sample for dry season; As, Se and Mn in water sample and Cd (both samples) for wet season were not within detection limit of AAS. Ca was still found to be the highest concentration in both samples for the two seasons. The orders of variability are: Cr > Mn > Pb > Zn > Ni > Cu > Fe > K > Na > Mg > Ca and Ni > Zn > Cr > Cu > Na > Mg > K > Ca > Fe for dry and wet seasons, respectively (Tables 2a and 2b).

The result of metal analysis of sediment and water

**Table 1b.** Metals concentration (ppm)[a] of sediments and ambient water in River Doma in wet season.

| Mineral | Sediments | Water | Mean | SD | CV% |
|---|---|---|---|---|---|
| Na | 4.73 ± 1.20 | 0.88 ± 0.20 | 2.81 | 1.93 | 68.68 |
| K | 2.48 ± 1.50 | 0.72 ± 1.50 | 1.6 | 0.88 | 55 |
| Ni | 1.12 ± 1.01 | ND | nd | nd | nd |
| Cu | 0.89 ± 1.50 | 0.19 ± 1.01 | 0.54 | 0.35 | 64.81 |
| Mg | 16.89 ± 2.50 | 6.81 ± 1.05 | 11.55 | 5.04 | 42.53 |
| Fe | 10.77 ± 0.60 | 0.72 ± 1.20 | 5.75 | 5.03 | 87.48 |
| Ca | 19.99 ± 150 | 8.56 ± 1.01 | 14.28 | 5.72 | 40.06 |
| Zn | 1.28 ± 0.50 | ND | nd | nd | nd |
| Pb | 0.82 ± 1.20 | 0.05 ±0.50 | 0.44 | 0.39 | 88.64 |
| Cd | ND | ND | nd | nd | nd |
| As | 0.87 ± 1.50 | ND | nd | nd | nd |
| Se | 0.59 ± 1.50 | ND | nd | nd | nd |
| Cr | 1.20 ± 0.20 | 0.10 ± 0.60 | 0.65 | 0.55 | 84.62 |
| Mn | 1.20 ± 1.05 | ND | nd | nd | nd |

ND = not detected; SD = standard deviation; CV% = coefficient of variation percent; nd = not determined; [a]Values are mean ± standard deviation of triplicate determinations

**Table 2a.** Metals concentration (ppm)[a] of sediments and ambient water in Farinruwa River in dry season.

| Mineral | Sediments | Water | Mean | SD | CV% |
|---|---|---|---|---|---|
| Na | 5.20 ± 2.50 | 2.89 ± 1.50 | 4.06 | 1.16 | 28.57 |
| K | 3.67 ± 1.50 | 1.86 ± 1.50 | 2.77 | 0.91 | 32.85 |
| Ni | 1.20 ± 1.60 | 0.20 ± 1.00 | 0.7 | 0.5 | 71.43 |
| Cu | 3.01 ± 1.00 | 0.65 ± 1.50 | 1.83 | 1.18 | 64.48 |
| Mg | 15.56 ± 2.50 | 9.95 ± 1.50 | 12.76 | 2.81 | 22.02 |
| Fe | 5.99 ± 1.50 | 1.94 ± 1.20 | 3.97 | 2.03 | 51.13 |
| Ca | 21.53 ± 2.50 | 14.05 ± 2.50 | 17.79 | 3.74 | 21.02 |
| Zn | 2.47 ± 0.50 | 0.32 ± 0.05 | 1.4 | 1.08 | 77.14 |
| Pb | 1.75 ± 0.00 | 0.20 ± 1.50 | 0.98 | 0.78 | 79.59 |
| Cd | 0.28 ± 1.00 | ND | nd | nd | nd |
| As | 1.94 ± 050 | ND | nd | nd | nd |
| Se | 1.10 ± 1.50 | ND | nd | nd | nd |
| Cr | 1.75 ± 2.10 | 0.11 ± 1.20 | 0.93 | 0.82 | 88.17 |
| Mn | 2.31 ± 1.10 | 0.19 ± 0.05 | 1.25 | 1.06 | 84.8 |

ND = not detected; SD = standard deviation; CV% = coefficient of variation percent; nd = not determined; [a]Values are mean ± standard deviation of triplicate determinations

samples from Mada River (Tables 3a and 3b) showed that Ca was also the highest concentrated metal for both seasons. The least concentrated metal was Cd (0.11 ppm) and Se (0.23 ppm) for dry and wet seasons, respectively. Metals that were not within the detection limit of AAS for both samples were: Cd, As and Se in water sample (dry season) and Zn, Pb and As (water sample) and Cd (both samples) (wet season). The orders of variability are: Mn > Ni > Pb > Fe > Cr > Zn > Cu > Na > Ca > Mg > K and As > Mn > Cr > Cu > Fe > Ca > Na > Mg > K > for dry and wet seasons, respectively.

Comparison of the mean levels of trace metals in sediment and ambient water samples from rivers Doma, Farinruwa and Mada is displayed in Table 4. Ca had the highest concentration in all the three rivers (sediment and water samples) ranging from 17.0 ppm in Doma River to 19.06 ppm in Mada River and 14.28 ppm in Doma to 15.84 ppm in Mada for dry and wet seasons, respectively followed by Mg (11.51 – 12.92 ppm) (dry season) and Mg (8.43 – 11.85 ppm) (wet season). Similar observations made by Aremu et al. (2008) and Aremu and Inajoh (2007) described Ca and Mg as the predominant minerals in surface and ground water. Mg functions as an essential constituent for bone structure, reproduction for

**Table 2b.** Metals concentration (ppm)[a] of sediments and ambient water in Farinruwa River in wet season.

| Mineral | Sediments | Water | Mean | SD | CV% |
|---|---|---|---|---|---|
| Na | 3.88 ± 2.50 | 1.03 ± 2.10 | 2.46 | 1.43 | 58.13 |
| K | 2.20 ± 2.30 | 0.90 ± 4.50 | 1.55 | 0.65 | 41.94 |
| Ni | 0.83 ± 2.50 | 0.90 ± 0.010 | 0.42 | 0.41 | 97.62 |
| Cu | 1.82 ± 1.50 | 0.17 ± 0.50 | 0.99 | 0.83 | 83.84 |
| Mg | 12.76 ± 2.50 | 4.10 ± 2.10 | 8.43 | 4.33 | 51.36 |
| Fe | 3.91 ± 1.50 | 0.91 ± 1.50 | 2.41 | 1.5 | 6.22 |
| Ca | 19.01 ± 5.50 | 11.00 ± 3.50 | 15.01 | 4.01 | 26.72 |
| Zn | 1.29 ± 1.00 | 0.07 ± 1.10 | 0.68 | 0.61 | 89.71 |
| Pb | 0.78 ± 1.50 | ND | nd | nd | nd |
| Cd | ND | ND | nd | nd | nd |
| As | 1.03 ± 2.30 | ND | nd | nd | nd |
| Se | 0.81 ± 1.50 | ND | nd | nd | nd |
| Cr | 0.90 ± 0.60 | 0.07 ± 0.50 | 0.49 | 0.42 | 85.71 |
| Mn | 1.75 ± 0.30 | ND | nd | nd | nd |

ND = not detected; SD = standard deviation; CV% = coefficient of variation percent; nd = not determined; [a]Values are mean ± standard deviation of triplicate determinations.

**Table 3a.** Metals concentration (ppm)[a] of sediments and ambient water in Mada River in dry season.

| Mineral | Sediments | Water | Mean | SD | CV% |
|---|---|---|---|---|---|
| Na | 6.11 ± 0.50 | 2.31 ± 1.10 | 4.21 | 1.9 | 45.13 |
| K | 3.25 ± 2.50 | 2.09 ± 1.20 | 2.67 | 0.58 | 21.72 |
| Ni | 1.65 ± 3.01 | 0.15 ± 2.10 | 0.9 | 0.75 | 83.33 |
| Cu | 3.12 ± 2.01 | 0.78 ± 2.50 | 1.95 | 1.17 | 60 |
| Mg | 14.36 ± 3.45 | 8.65 ± 2.50 | 11.51 | 2.86 | 24.85 |
| Fe | 13.45 ± 2.01 | 2.01 ± 1.50 | 7.73 | 5.72 | 74 |
| Ca | 24.97 ± 0.10 | 13.15 ± 2.50 | 19.06 | 5.91 | 31.01 |
| Zn | 1.02 ± 1.01 | 0.24 ± 1.50 | 0.63 | 0.39 | 61.9 |
| Pb | 0.76 ± 1.03 | 0.09 ± 1.01 | 0.43 | 0.34 | 79.07 |
| Cd | 0.11 ± 1.01 | ND | nd | nd | nd |
| As | 1.57 ± 2.00 | ND | nd | nd | nd |
| Se | 0.95 ± 1.30 | ND | nd | nd | nd |
| Cr | 2.61 ± 1.40 | 0.55 ± 2.10 | 1.58 | 1.03 | 65.19 |
| Mn | 1.95 ± 2.01 | 0.19 ± 0.40 | 1.57 | 1.38 | 87.9 |

ND = not detected; SD = standard deviation; CV% = coefficient of variation percent; nd = not determined; [a]Values are mean ± standard deviation of triplicate determinations.

normal functioning of various other systems. It also forms part of the enzyme system (Shills and Young, 1988). Ca plays an important role in blood clotting, in muscular contractions and in some enzymes assisting in metabolic processes. Ca tends to be a coordinator among inorganic elements, such that when K, Mg and Na are present in quantities beyond a particular limit in the body, Ca assumes a corrective role (Fleck, 1976). The Ca and Mg levels in all the sediment/water samples fall within the WHO (1993) recommended range of values. These are desirable for drinking without adverse effect. WHO recommended a maximum Ca level of 200 ppm above which values deposition of $CaCO_3$ in water systems can lead to major problems. On the other hand, the permissible level of Mg is fixed at 150 ppm provided the sulphate concentration is less than 250 ppm.

Potassium concentrated values ranged from 2.67 ppm in Mada River to 3.46 ppm in Doma while the values for Na varied from 4.06 – 4.23 ppm. K is primarily an intracellular cation found mostly bound to protein in the body along with sodium where they influence osmotic pressure and contribute to normal pH equilibrium (Fleck,

**Table 3b.** Metals concentration (ppm)[a] of sediments and ambient water in Mada River in wet season.

| Mineral | Sediments | Water | Mean | SD | CV% |
|---|---|---|---|---|---|
| Na | 3.87 ± 1.50 | 1.76 ± 1.50 | 2.82 | 1.06 | 37.59 |
| K | 1.88 ± 1.50 | 0.98 ± 1.10 | 1.43 | 0.45 | 31.47 |
| Ni | 0.72 ± 1.10 | ND | nd | nd | nd |
| Cu | 2.30 ± 1.50 | 0.13 ± 0.10 | 1.22 | 1.09 | 89.34 |
| Mg | 13.24 ± 2.30 | 5.99 ± 0.15 | 9.62 | 3.63 | 37.34 |
| Fe | 12.62 ± 1.50 | 0.83 ± 1.03 | 6.73 | 5.9 | 87.67 |
| Ca | 23.20 ± 0.40 | 8.47 ± 1.05 | 15.84 | 7.37 | 46.53 |
| Zn | 0.90 ± 0.10 | ND | nd | nd | nd |
| Pb | 0.26 ± 1.50 | ND | nd | nd | nd |
| Cd | ND | ND | nd | nd | nd |
| As | 0.73 ± 1.03 | ND | 0.37 | 0.36 | 97.3 |
| Se | 0.23 ± 1.50 | ND | nd | nd | nd |
| Cr | 2.12 ± 1.50 | 0.11 ± 1.05 | 1.12 | 0.11 | 91.67 |
| Mn | 1.88 ± 1.20 | 0.08 ± 2.05 | 0.98 | 0.9 | 91.84 |

ND = not detected; SD = standard deviation; CV% = coefficient of variation percent; nd = not determined; [a]Values are mean ± standard deviation of triplicate determinations.

**Table 4a.** Mean levels of metals concentration (ppm) in Rivers Doma, Farinruwa and Mada compared in dry season.

| Mineral | Doma River | Farinruwa River | Mada River | WHO in ppm | FEPA in ppm |
|---|---|---|---|---|---|
| Na | 4.23 | 4.06 | 4.21 | na | na |
| K | 3.46 | 2.77 | 2.67 | na | na |
| Ni | 1.69 | 0.7 | 0.9 | 0.05 | < 1.0 |
| Cu | 1.43 | 1.83 | 1.95 | 1 | 2.0 – 4.0 |
| Mg | 12.92 | 12.76 | 11.51 | 30 | < 30 |
| Fe | 6.04 | 3.97 | 7.73 | 0.3 | 1 |
| Ca | 17 | 17.79 | 19.06 | 45 | < 45 |
| Zn | 1.6 | 1.4 | 0.63 | 5 | 20 |
| Pb | 0.76 | 0.98 | 4.5 | 0.05 | < 1.0 |
| Cd | nd | nd | nd | 0.005 | 1.8 |
| As | nd | nd | nd | 0.05 | 0.5 |
| Se | nd | nd | nd | 0.01 | na |
| Cr | nd | 0.93 | 1.58 | 0.05 | < 1.0 |
| Mn | 1.26 | 1.25 | 1.57 | 0.01 | 0.05 |

**na =** not available; **nd =** not determined

1976). The Na content in water is important for healthy reasons, except when combined with excessively high concentrations of sulphate. Such combinations can lead to gastrointestinal initiation for persons placed on low Na diet as a result of heart, kidney or circulatory ailment or complications of pregnancy. The usual low Na diet allowed in drinking water is 20 ppm (Ademoroti, 1996). The values recorded for both K and Na in the present study fall within the WHO limits. Thus, the samples of water from the different sources are good for consumption as far as these cations are concerned. The high iron content and its wide distribution throughout the sampling points (Tables 1A, 1B, 3A and 3B) reflect its presence at high concentration in Nigerian soils (Aiyesanmi, 2006; Aremu et al., 2010; Kakulu and Osibanjo, 1988). Iron is one of the essential components of haemoglobin which is responsible for the transport of oxygen in the body. It also occurs in the prosthetic group of the cytochromes which function in election transport and in some enzymes like the dehydrogenases (Wheby, 1974). Iron also facilitates the oxidation of carbohydrates, proteins and fats. It therefore contributes significantly to the prevention of anaemia, which is widespread in developing countries like Nigeria (Bender, 1992). The

**Table 4b.** Mean levels of metals concentration (ppm) in Rivers Doma, Farinruwa and Mada compared in wet season.

| Mineral | Doma River | Farinruwa River | Mada River | WHO in ppm | FEPA in ppm |
|---|---|---|---|---|---|
| Na | 2.81 | 2.46 | 2.82 | na | na |
| K | 1.6 | 1.55 | 1.43 | na | na |
| Ni | nd | 0.42 | nd | 0.05 | < 1.0 |
| Cu | 0.54 | 0.99 | 1.22 | 1 | 2.0 – 4.0 |
| Mg | 11.85 | 8.43 | 9.62 | 30 | < 30 |
| Fe | 5.75 | 2.41 | 6.73 | 0.3 | 1 |
| Ca | 14.28 | 15.01 | 15.84 | 45 | < 45 |
| Zn | nd | 0.68 | nd | 5 | 20 |
| Pb | 0.44 | nd | nd | 0.05 | < 1.0 |
| Cd | nd | nd | nd | 0.005 | 0.2 – 1.80 |
| As | nd | nd | 0.37 | 0.05 | 0.5 |
| Se | nd | nd | nd | 0.01 | na |
| Cr | 0.65 | 0.49 | 1.12 | 0.05 | < 1.0 |
| Mn | nd | nd | 0.98 | 0.01 | 0.05 |

**na** = not available; **nd** = not determined.

iron contents in all the water samples (Tables 1A, 1B, 3A and 3B) are higher than WHO/USEPA value of 0.30 ppm for drinking water (USEPA, 2002). This is not unacceptable to the consumers but could give rise to iron-dependent bacteria which in-turn can cause further deterioration in the quality of water through the development of slimes and or objectionable odour. The result obtained may be due to run-offs and geological formations of the sample locations (Aremu et al., 2008). Lead concentration levels ranged from 0.45 ppm in Mada River to 0.98 ppm in Farinruwa (dry season) and 0.15 ppm in Mada River to 0.44 ppm in Doma (wet season). Lead even at low concentration is known to be toxic and has no known function in biochemical process. It can impair the nervous system and affect foetus, infants and children resulting in lowering of intelligent quotient (IQ) even at its lowest dose (UN, 1998).

The onset of lead pollution of surface waters in Nigeria has been reported (Mombershora et al., 1983; Okoye, 1991). Lead sticks to soil particles and enters drinking water only if the water is acidic or soft. However, lead content values in the present study (Tables 1A, 1B, 3A and 3B) are higher than WHO/USEPA recommended value of 0.05 ppm. Cu and Zn are essential metals and play an important role in enzyme activity (NAS, 1971). The Cu and Zn contents in the present study for all the water samples (Tables 1A, 1B, 3A and 3B) (both seasons) were found to be within the permissible limits of WHO/USEPA standards. Similar observation was made by the Federal Ministry of Environment on water standards for aquatic life to which most metals conform (FME, 2001). However, because a metal concentration in the aquatic environment is low and considered to be naturally occurring or background, does not mean that the concentration could not cause adverse ecological effects (USEPA, 2002). The presence of one metal can significantly affect the impact that another metal may have on an organism. The effect can be synergistic, additive or antagonistic (Eisler, 1993). Cd, As and Se were below the detection limit of AAS for all the water samples (Tables 1A, 1B, 3A and 3B) (both seasons). They were found to be present in sediments. Some of the diseases caused by Se to mammals include accumulation of fluid throughout the body and destructive damage to the liver.

The early symptoms of acute toxic effects of Se are sore throat, fever, vomiting, irritation to eyes and nose, headache, drop in blood pressure, dermatitis and garlic odour of the breath (Luckey and Venugopal, 1977). As has been implicated in lung cancer, especially when the arsenic compound inhaled is of low solubility. It has also been found to have an effect on the liver by causing a disease termed cirrhosis and a rare form of liver cancer called haemongioendothelioma (Hutton, 1987). Cr levels ranged between 0.93 – 1.58 ppm (dry season) and 0.49 – 1.12 ppm (wet season). The metal is essential for life; its deficiency results in diabetic mellitus and increases the toxicity of lead (Aremu et al., 2010). Mn is an essential element and one of moderate toxicities. Its levels of concentration in the rivers varied between 1.25 – 1.57 ppm (dry season) and (nd – 0.98 ppm) (wet season) (Tables 4A and 4B). Mn has been implicated in neurological problems, especially when inhaled.

## Conclusion

This study has presented metal concentrations (Na, K, Ni, Cu, Mg, Fe, Ca, Zn, Pb, Cd, As, Se, Cr and Mn) in sediment and water samples collected from Rivers Doma, Farinruwa and Mada located in Nasarawa State, Nigeria. The results revealed that there was an indication of some heavy metals (Ni, Fe, Pb and Mn) pollution in all the water samples because their contents were found to be higher than WHO/USEPA recommended values. This work therefore will serve as baseline information for future work.

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