International Conference on Developmental Sciences and Technologies, Federal University of Agriculture, Abeokuta, Nigeria. 27 – 30 August, 2019.
https://unaab.edu.ng/2020/06/colphysproceedings/

Evaluation of Lead and Cadmium Contents in Different Water Sources using Chemical Fractionation Method

Oluwole J. Okunola[1]*, Saheed G. Adewusi [2] and Sunday Achimugu [1]

[1]Department of Applied Chemistry, Federal University Dutsin-Ma, Dutsin-Ma, Katsina State, Nigeria.
[2]Department of Chemistry, Federal College of Education, Zaria, Kaduna State, Nigeria.
*Corresponding Author E-mail: ookunola@fudutsinma.edu.ng

Abstract

The study was aimed at evaluating Cd and Pb concentrations in different water sources; pipe borne water, hand-dug well, bore-hole and raw water from the dam in Dutsin-Ma town using chemical fractionation method. The sampling was carried in four (4) different locations around the Federal University Dutsin-Ma take-off campus. The pH of samples was determined *in-situ* and chemical fractionation of samples for Pb and Cd was carried out using standard method. The results of the pH values showed that majority of the samples has pH ranged not within the recommended limits for drinking water quality. The mean range of the metals determined in different fractions revealed: 0.294 - 0.994 mg/L for Pb and 0.650 – 2.533 mg/L for Cd. The results showed that Cd and Pb concentrations in all the water fractions (mobile, dissolved, total and particulate) are above the WHO recommended limit of 0.003 and 0.01mg/L in drinking water. The findings complement the trend of poor sanitary and monitoring system of water sources in Nigeria. Indiscriminate dumping of refuse in water ways, uncovered wells, rusty pipes and poor functionally of water treatment plant were identify to be main course of poor water quality in the town.

Keywords: Fractionation,Water Sources, Cadmium, Lead, Dutsin-Ma

1. Introduction

Water is life, and is essential for all forms of growth and development, this includes plants and animals (Ogedengbe and Akinbile, 2004; Vanloon and Duffy, 2005), and it is obtained from two principal natural sources; surface water such as fresh water lakes, rivers, streams and ground water such as borehole water and well water (Mendie,2005). Water has a unique chemical properties due to its polarity and hydrogen bond which makes it is able to dissolve, absorb and suspend many compounds (WHO, 2008). Thus in nature, water is not pure as it acquires contaminants from the surrounding and those arising humans and animals as well as other biological activities (Mendies, 2005).

Dustin-Ma water resources of recent, have been threatened by the population growth due to the location of the Federal University coupled with other economic activities that follows. This has culminated into generation of large municipal waste worsen by poor disposal system which has increased the level of heavy metals in water source to the water works (Okunola and Mainasara, 2016). One of the major pollutant of water resources in Dutsin-Ma is heavy metals, some of which has no beneficial use to human and aquatic animals (Mebrahtu and Zebrabruk, 2011)

In addition, heavy metals become toxic when their concentrations are above the threshold recommended thereby damaging the life functions of an organism (Albergoni and Piccinni, 1983; Kumar and Puri, 2012). Metals in natural waters can exist in truly dissolved colloidal and suspended forms. The proportion of these forms varies with metals and for different water bodies. Consequently, the toxicity and sedimentation potential of metals change depending on their forms (Marcovachia *et al*., 2007). Non-essential metals often exert their action through their chemical similarity to essential elements for example, cadmium with copper or zinc (Marcovachia *et al*., 2007).

With increase in water utilization and consequential health implications to the residents coupled with paucity of literatures on the forms of heavy metals in different water sources. Hence, it becomes imperative to carry out this study. Therefore, the aim of the research was to determine the concentrations of Cadmium (Cd) and lead (Pb) in different sources of water in Dustin-ma using chemical fractionation method.

2. Materials and Methods

2.1 Study Area

Dutsin-Ma is a local government in Katsina State of Nigeria, located in the Sudan savannah zone in the central Katsina State relatively bounded by Safana and Dan-Musa Local Governments to the north. In Dutsin-Ma town, about 80% of its population lives in rural areas fully engaged in agricultural production. It has an annual rainfall of 400 – 660mm^3 with an annual temperature range of 17 – 42^{0}C. The population of Dutsin-Ma was estimated to be 169,671 as at 2006 Census. However, since 2012, Dutsin-Ma area has witness increase in population and human activities due to the location of the Federal University.

2.2 Sample Collection

Water samples were collected from four different sources of water in Dutsin-ma, this includes; raw water from the dam (DW), Pipe-borne (TW), borehole (BH) and underground water (WW). The samples were collected in the month of June, 2016 during the early hour of the day between 6:30 and 11:57 am. For the samples collection; Dutsin-ma town was stratified into four zones. **Zone(I):** Darawa, **Zone(II):** Kadangaru, **Zone(III):** Sokoto Rima and **Zone(IV):** Hayingada. Four (4) grab samples were collected from each zone per source of water, then pooled together to give composite sample for a source. Samples were analyzed in duplicates.

2.3 Determination of pH

The pH of samples was taken *in-situ* using the HANNA instrument HI 8014.The sensor was held in the sample until the pH value was stabilized within a one decimal range. Between the readings, the sensor was cleaned or rinsed in distilled water. The pH meter was calibrated before use using buffer solution of pH 4 and 9.

2.4 Chemical Fractionation of Samples

Chemical fractionation of water samples was carried out on the principle proposed by Backstrom *et al*. (2003). Samples were subjected to extraction separately using 3.2 ml of 65 %$^v/_v$ concentrated HNO_3 to give 2% HNO_3acidification in 100 ml of sample. The extraction was aimed at differentiating fractions in three stages as follows:

Fraction I (Dissolved):96.8ml of the water sample was decanted from the sample bottle and filter through 0.5µm Teflon filter paper before acidification. .

Fraction II(Mobile): 96.8ml of the water samples is decanted from the sample bottle and acidified followed by filtration through 0.5µm Teflon filter paper after 24 hours.

Fraction III (Total):3.2 ml of concentrated nitric acid was added directly into 96.8 ml of sample in the bottle and shaken vigorously to suspend all particulate matter. The solution is then filtered after 24 hours through the 0.5µm Teflon filter paper.The particulate concentration was calculated as the difference between Fraction III and Fraction I.

For each sample treatment, sample in each beaker is then poured into the separating funnel in drops through the syntax glass containing the Teflon filter paper to filter the residue thereby collect the filtrate in the sampling bottle as shown in **Plate I**.

Plate I: Set-up of filtration process

3. Result and Discussion

3.1 pH of Water Samples

pH range from 4.66 (RW) to 8.30 (WW) as shown in Table 1. The maximum pH value 8.30 is within the WHO recommended value for drinking water quality. The pH of raw water falls below the WHO standard for drinking water quality. pH can be influenced by various chemicals, and biological processes, geographical and environmental processes. It may be concluded that drinking water from boreholes, and tap-water in dutsin-ma metropolis is suitable for drinking and other domestic chores, as they fell within the recommended standard values, except for (RW_1 ,RW_2) which falls below the threshold limit values of (4.5- 8.5) was confirmed. The analysis of variation (ANOVA) test shows significant different in pH values at various point. The mean pH values along the point are similar to typical values as (4.5-8.5) reported by Mccutchen *et al*. (1992).

3.2 Cadmium

The results of chemical fractionation of different water samples for Cd is presented in Figure 1. The concentrations of Cd ranged from 0.650 – 1.53 mg/L, 0.683 – 1.900 mg/L, 0.717 – 2.533 mg/L and 0.066 – 1.117 mg/L for dissolved, mobile, total and particulate fractions. The highest concentration of Cd fraction for all samples was obtained in dam water (DW) sample with exception of particulate fraction which presented highest concentration for well water (WW). Analysis of variation (ANOVA) among the samples fractions showed the statistical differences of Dissolved = 0.079, Mobile = 0.025, Total = 0.005, and Particulate = 0.074 of different fractions. The results in this study showed that Cd is above the recommended limit of 0.003 mg/L (WHO, 2011). Analyses of relationship among the fractions for Cd are shown in Table 2. Significant correlations ($p < 0.05$) observed among the fractions indicates that the sources Cd in these fractions are same.

However, availability of Cd in the dissolved and mobile fractions couple with their high concentrations in these fractions indicate risk of Cd to human through direct ingestion. Accumulation of Cd above the recommended limits causes acute and chronic poisoning of the liver and may also replace calcium in the bone of the young children (Heyes, 1997). However, filtration using micro-filter could remove particulate fraction of the metal thereby improving the quality of the water

3.3 Lead

The mean concentration of Pb in different fractions of the water using chemical fractionation methods are presented in Figure 2. Analysis of variation (ANOVA) among the fractions showed statistical differences; Dissolved is 0.582, Mobile is 0.912, Total is 0.504, and Particulate is 0.904. The concentrations of Pb varied from 0.292 mg/L (BH) – 0.798 mg/L (DW) for dissolved fraction, 0.361 mg/L (BH) – 0.622 mg/L (TW) for mobile fraction, 0.409 mg/L (BH) – 0.994 mg/L (BH) for total fraction and 0.093 mg/L (TW) – 0.192 mg/L (DW) for particulate fraction. The highest concentration of 0.994 mg/L was recorded for sample DW of total fraction. Similarly, the values obtained in different water fractions for Pb is above recommended limit of 0.01 mg/L for drinking water (WHO, 2011). According to Watershed Protection Plan Development Guidebook (2005), Pb can cause a variety of neurological disorders. In children, it inhibits brain cell development. The analyses of relationship among the fractions for Pb are shown in Table 3. Significant correlations ($p < 0.05$) observed among the fractions indicates that the sources of these fractions are same.

Table 1: pH of different water sources

Sample	TP1	TP2	RW1	RW2	BH1	BH2	WW1	WW2
pH	6.51	7.02	4.66	4.87	5.57	5.80	8.30	7.58

Table 2: Correlation among Cd fractions in water

Parameter	$Cd_{Dissolved}$	Cd_{Mobile}	Cd_{Total}	$Cd_{Particulate}$
$Cd_{Dissolved}$	1.000			
Cd_{Mobile}	0.857**	1.000		
Cd_{Total}	0.822*	0.958**	1.000	
$Cd_{Particulate}$	0.456	0.773*	0.880**	1.000

***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*

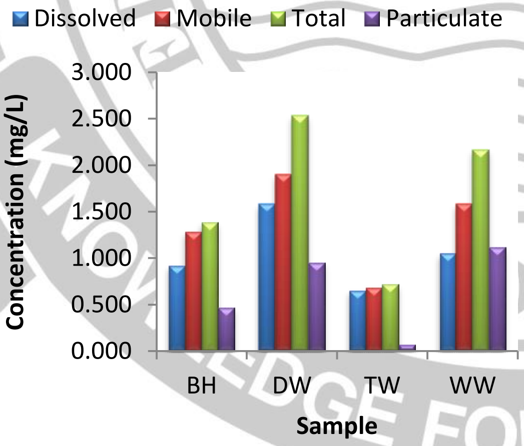

Figure 1: Concentration of Cd in different fraction of water sources

Table 3: Correlation among Pb fractions in water

Parameter	$Pb_{Dissolved}$	Pb_{Mobile}	Pb_{Total}	$Pb_{Particulate}$
$Pb_{Dissolved}$	1.000			
Pb_{Mobile}	0.400	1.000		
Pb_{Total}	0.937**	0.574	1.000	
$Pb_{Particulate}$	0.022	0.579	0.369	

***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*

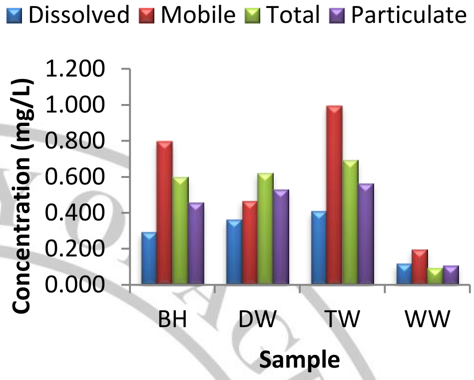

Figure 2: Concentration of Pb in different fraction of water sources

4.0 Conclusions

The results obtained in the study showed the trend of various fractions of Cd and Pb in different sources of water in Dutsin-Ma Town, Katsina State. The concentrations of Cd and Pb fractions in all the samples collected were above the standard recommended limits of WHO for drinkable water. High concentrations of the metals in the fractions; disolved and mobile fractions indicate great risk to consumers of the water sources, since these fractionation may not be easily removed by simple filtration process. Indiscriminate dumping of refuse in water ways, uncovered wells, rusty pipes and poor functionally of water treatment plant were identify to be main course of poor water quality in the town.

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