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Determination of Trace Metal Concentrations in Raw and Treated Drinking Water from Lower Usuma Dam in Federal Capital Territory (F.C.T) Abuja, Nigeria

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ABSTRACT

Concentrations of Cd, Cu, Pb, Ni and Zn were determined in the surface water of Usuma Dam and in the treated drinking water from the same source using Atomic absorption spectrophotometry. The concentrations of Cd, Cu, Pb, Ni and Zn in the surface raw water were 7.0, 17.0, 24.1, 14.0 and 43 µgl^{-1} respectively. While their concentrations in the treated drinking water were 5.0, 10.0, 18.0, 9.0 and 25.3 µgl-1 respectively. The trend of the concentration is in the order of Zn > Pb> Cu> Ni> Cd in both the water samples. The result shows that the metal concentrations in the treated drinking water are lower than the metal concentration in the raw water. This may be attributed to water treatment processes and distribution.

Introduction

The entire environment is made up of land, air, water and living things. These three components were created purely for human and are indispensible to us[1].

Environmental pollution has become a threat to the continued existence of plants and animals and may ultimately threaten the quality of human life[6]. the release of wide range of toxic metals and metalloids into the environment as a result of man's activities like industrialization, agricultural waste, automobile exchange e.t.c are some of the most dangerous forms of environment pollution.

Several incidence of heavy metal pollution which result in disease in different part of the world, such incident trigger the industrially developed countries to give more consideration on this type of pollution. e.g. in 1956 cases of minamata disease were reported in Japan[1]. the disease was due to pollution of water by industrial waste containing methyl mercury. Also the itai-itai disease caused by cadmium, the farmers in jinzu river region suffered from this diseases. As a result of cadmium which was discharge in the water[1].

Most cities and towns are facing problems of solid waste management, for instance some of the gutters and road sides in residential areas of Abuja municipality have become dumping grounds and defecation place which result in the pollution of land and water.

Usuma Dam as the main source of drinking water for almost all the inhabitants of the Abuja Municipality and some of the area council.[4] possible contamination of the source of drinking water by discharges containing pesticides, sewage nutrients. and heavy metals can easily cause a serious health hazards either directly or indirectly to the living organism,. continuous monitoring of the levels of these contaminants is very vital.

Nickel is a moderately toxic element as compared with other transition metals. However, it is known that inhalation of nickel and its compound can lead to serious health problems including respiratory cancer. Moreover, nickel can cause a skin disorder known as nickel-eczema[2].. Cadmium is known to be highly toxic for animals, plants and humans even at low concentrations and can be accumulated in several organs. The most important anthropogenic sources of this elements include emission from industrial plants, such as zinc smelter, steel waste, incenrator and power station[3].

Zinc is an essential trace element of great importance for humans, plants and animals. Zinc deficiency slows growth and development and also lead to cognitive defects and impairs the immune system. An excess of the metal can play an important role in the progression of several damages to human body, including disturbance in energy metabolism or increase in oxidative stress.[10].

Lead is one of the most widespread heavy metals in the environment in view of its extensive use in storage batteries, solders, cable sheath, pigments anti knocks products and radiation shields and due to corrosion of house hold plumbing system. The consumption of lead contaminated drinking water causes delay in physical or mental development, slight deficit in learning abilities of children, high blood pressure and kidney problems in adult[12].

This research work has aimed at determining the trace metal concentration in the raw water of Usuma Dam and their corresponding concentration in the treated drinking water in Abuja Muncipality.

Despite the selectivity and sensitivity of analytical techniques such as atomic absorption spectrometry, there is a crucial need for the separation and preconcentration, and preconcentration before their analysis, due to their low

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concentrations in numerous samples.[14]. In trace metals analysis, preconcentration and/or separation of trace elements from the matrix is frequently necessary to improve the detection limit and selectivity for their determination by FAAS. Several methods have been proposed and used for preconcentration and separation of trace element according to the nature of the samples, the concentration of the analytes and the measurement techniques[15]. These include ion exchange, solvent extraction, coprecipitation, cloud poultry extraction, electrodeposition and solid phase extraction (SPE).

Water treatment and distribution tends to reduce concentration of trace metal in water.[5].

Low blank pre concentration techniques was used for the determination lead copper and cadmium in small volume of sea water by isotope dilution ICPMS[15].

The concentration of lead and cadmium was also determine in Nile River water and finished drinking water in a greater Cairo Egypt.[6] (Mohammd & Osman 1998).

2. Materials and Methods

Chemicals of analytical grade purity and deionized water were used for the preparation of reagents. All apparatus were thoroughly wash with detergent solution, tap water and finally rinsed with distilled water. A pye unicorn Atomic absorption spectrophotometer modal SP9 was used for the determination.

2.1 Sampling

The water samples were collected twice at six different locations of the Dam for a period of six months i.e. April, to September. The water samples were obtained using a small hand pump to fill clean polyethylene bottles and then acidified with 5cm^3 of concentrated nitric acid and stored in a refrigerator, before the analysis. The treated drinking water was also collected and filtered twice monthly[11].

The stock solutions of all the metals to be determined were prepared and also the working standard solution of the metals were prepared by serially diluting appropriate volumes of standard stock solutions of the metals with distilled water to give metal concentration in the working range.

500cm^3 of the sample was transferred into a glass beaker and evaporated on a hot plate to approximately 25ml^3. after cooling the solution was filtered quantitatively to a volumetric flask and diluted to 50cm^3 with distilled water.[9] Alternatively Ammonium Pyrolidine Dithio Carbamate (APDC) and Methyl Isobutyl Ketone (MIBK) can be used[7].

Sample digests were analysed for metals using the flame atomic absorption spectrophotometer described above. The absorbance of each sample is an average of four measurements.

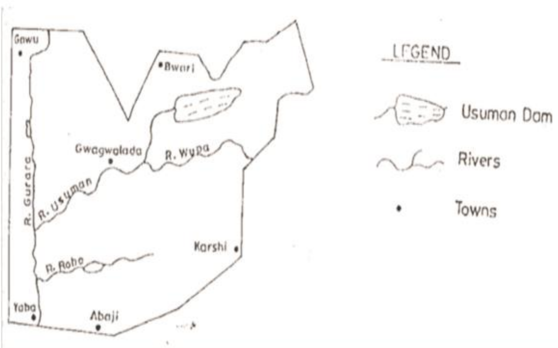

Fig. 1. Map of FCT Abuja showing River Usuman Dam.

3. Results and Discussion

From the results of concentration of trace metals determined in the raw and treated drinking water (Table 1 and 2) there is a decrease in the concentration from the raw to the treated drinking water. The order of concentration of the metals in water is Zn> Pb> Cu> Ni> Cd. For instance, the mean Zn concentration in the treated drinking water is 25.3 + 2.0µgl^{-1}. Compared with 43±8.0 µgl^{-1}. In the raw water, the mean Pb concentration in the treated drinking water is 18±2.0µgl^{-1} compared with 24.1±7.3µgl^{-1} in the raw water. The mean Cu concentration in treated drinking water is 10±1.8µgl^{-1} compared with 17.0±3.0µgl^{-1} in the raw water. The mean Ni concentration in the treated drinking water is 9.0±2.2µgl^{-1} compared with 14.0±5.0µgl^{-1} in the raw water. The mean Cd concentration in treated drinking water is 5.0±1.2 µgl^{-1} compared with 7.0±2.2 µgl^{-1} in the raw water.

Generally the levels of most metals in the water samples were within safe limits prescribed by the World Health Organisation (WHO). (World Health Organization, 1971)

The metal concentrations in this study are lower than World Health Organization guidelines and those of the United State of America. (World Health Organization, 1971)

The metal levels in this study are a little higher than the levels obtained in Niger Delta surface water[7] and that of Nile River Water.[6].

The decrease in the concentration of the trace metals from the raw water to the treated drinking water can be attributed to processes which the water undergoes during treatment and distribution, for example sedimentation, filtration, pH and softening, all these factors affects the concentration of the trace metals in water.[6]

Table 1. Mean metal concentration (μgL^{-1}) in treated drinking water from all individual samples for the period of April to September.

MONTH	METALS				
n = 12	**Cd**	**Cu**	**Pb**	**Ni**	**Zn**
APRIL	5.0±2.0	8.0±1.0i	20±2.0	3.0±1.0	30±1.0
MAY	4.0±1.0	9.0±2.0	4.0±1.0	10±4.0	35±3.0
JUNE	3.0±1.0	10±1.0	40±3.0	6.0±1.0	27±2.0
JULY	4.0±2.0	10.0±2.0	3.0±1.0	20±2.0	4.0±1.0
AUGUST	10±1.0	12.0±3.0	30±2.0	4.0±2.0	36±3.0
SEPTEM BER	4.2±1.0	11±2.0	10±2.0	10±3.0	20±1.0
MEAN	5.0±1.3	10±1.8	18±2.0	9.0±2.2	25.3±2.0
RANGE	1-18	2-27	5-50	5-32	5-50

Where n = Number of Determinations for each month.

Table 2.Mean metal concentration (μgL^{-1}) in raw water from all individual samples for the period of April to September .

MONTH	**METALS**				
n = 12	**Cd**	**Cu**	**Pb**	**Ni**	**Zn**
APRIL	4.0±2.0	11.0±2.0	33±2.0	11.0±4.0	43±2.0
MAY	7.0±2.0	12.0±2.0	6.3±2.0	7.0±2.0	40±2.0
JUNE	6.0±1.0	26.0±1.0	43±6.0	9.0±2.0	31±1.0
JULY	11±6.0	26.0±4.0	7.0±2.0	35±10	48±10
AUGUST	7.0±1.0	14.0±2.0	45±20	7.0±3.0	43±10
SEPTEM BER	4.0±1.0	10.0±6.0	10±2.0	13.0±8.0	50±10
MEAN	7.0±2.2	17.0±3.0	24.1±7.3	14.0±5.0	43±8.0
RANGE	1-20	3-40	5-80	5-30	10-100

Where n = Number of Determinations for each month.

Table 3. correlation values between Metals in the Raw Water from all individuals samples.

	Cd	cu	pb	Ni	Zn
Cu	0.731				
Pb	-0.343	-0.006			
Ni	0.749	0.473	0.505		
Zn	0.169	0.0318	0.582	0.501	

Table 4. Correlation Values between Metals in the Treated drinking water from all individual samples.

	Cd	**Cu**	**pb**	**Ni**	**Zn**
Cd					
Cu	0.627				
Pb	0.289	0.249			
Ni	-0.377	0.455	-0.698		
Zn	0.401	0.355	0.442	-0.853	

A correlation studies was carried out between metals using Pearson correlation coefficient. R which is the correlation coefficient given by

$$R_{xy} = \frac{N\sum xy - (\sum x)\ (\sum y)}{\sqrt{(N \sum x^2 - (\sum x^2)\ (N\sum y^2 - (\sum y)^2)}}$$

Where R = correlation coefficient

N = number of replicate

X and y are individual values of each set of data.

The correlation values between metals in the raw and treated drinking water have been presented in Table 4.3 and 4.4 There is correlation between copper and cadmium also there is correlation between Nickel and Cadmium with R values 0.731 and 0.749 respectively. (Table 4.3). there is a slight correlation between Nickel and copper, together with Zinc and Nickel with R value 0.473 and 0.500 respectively. There is slight correlation in opposite direction between Nickel and lead then Zinc and lead.

It is finished drinking water sample there is correlation between copper and cadmium R (0.627) and slight correlation in opposite direction between Nickel and read r (-0.689) and negative correlation between zinc and nickel r (-0.853).

4. Recovery Analysis

Recovery studies of the metals in the water samples were carried out in order to determine the extent of accuracy of the whole analysis. This is carried out by adding a known quantity of a standard solution of the individual metals to different water samples marked (A1 A2 A3 A4 A5) table 3.2 The amount of analyte is then determined. The amount of the analyte determine in the blank water sample and that which is determined from the combination of the water sample and the standard solutions.

Cadmium has an average percent recovery of 79.4%, lead has an average percent recovery of 77.2% copper has an average percent recovery of 79%, Nickel has an average percent recovery of 80.8% and zinc has a average percent recovery of 81.0%

The result shows that a good amount of the metals were recovered.

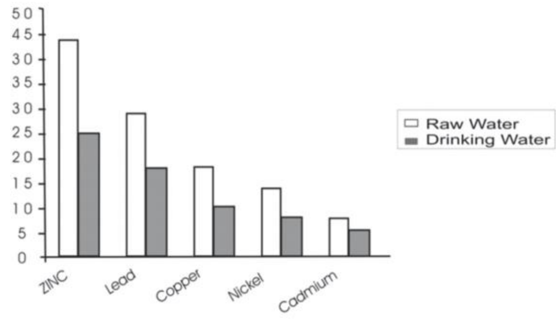

Fig. 2. Mean metal concentration in the raw and treated drinking water.

5. Conclusion

The concentration of trace metals and their variations in raw water supplies are of prime importance in relation to the ultimate quality of the treated drinking water reaching the consumer. One should then expect that raw water variabilities both geographically and with time would be reflected in the treated drinking water.

The averages found in this study are lower than the international averages for drinking water standards. Also the result shows that there is a general decrease in the concentration of the metals form the raw to the treated drinking water which is possibly due to the combined effect of treatment facilities and distribution of the water. The low concentration of the metals in Usuma Dam suggest that their possible source are mainly natural, atmospheric fall out and long range transport rather than anthrophegenic. Also factors like depth of the water, biological process, rapid form over rate of water, biological process, rapid form over rate of water can also affect the concentration of these metals in the raw water. This work would serve as baseline study for future research.

Table 5. comparison of metal levels in the water of Usuma Dam (Raw and Treated) with international average for fresh water, sea water and some drinking water standards conc. µgl^{-1}

Area of study	**Metals**				
	Cd	**Pb**	**Cu**	**Ni**	**Zn**
Usuma Raw Water	7.0	24.1	17.0	14.0	43
Usuma Finished Drinking	5.0	18.0	10.0	9.0	25.3
Niger Delta Surface	2.61	8.08	11.29	6.00	15.21
Water	0.67-2.92	2.0-	3.23-34.03	2.0	4.5
Int'l Average Fresh Water	80a	5	10	-	10
Sea Water	0.1	0.03	3	-	10
WHO	10	100	50	-	5,000a
USA	10a	5a	100a	-	5,000a
Remote Site in Newzeland	0.01-0.5b	0.04 -0.5b	2.0 -3.0b	0.01-0.4b	0.5-5b
Lacke Superior Ontario Surface Water	2.8-4.5b	3.2-11b	2.0 -3.0b	0.02-0.3b	87-277b
Nile River Water	4.15a	29.6a	-	-	-
Pangnitung Island Surface Water	0.02a	0.05 – 0.19b	0.045– 0.13b	-	0.02-0.24
Coastal Sea Water	-	1.22a	2.15	0.62	9.10

Note: a = Mean

B = range

= information not available in the original teixt.

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