Quantitative Analysis of some Toxic Metals in Domestic Water obtained from Lagos Metropolis

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ABSTRACT

Toxic metals are dangerous to human health if present in water at concentrations above the Environmental Protection Agency (EPA) maximum contaminant level (MCL). At low concentrations they accumulate in the organs after some years and may pose great risk to human health. Cadmium, lead, arsenic and chromium concentration in domestic water samples collected from different locations in Lagos metropolis were studied.

The contaminant level of cadmium, lead, arsenic and chromium in some brands of packaged water, well water and tap water randomly selected were determined. The samples were analysed using the atomic absorption spectrophotometer (AAS) and the concentrations were obtained by calibration plot method using the regression equation. The toxic metals, lead, cadmium, arsenic and chromium were detected in all the water samples analysed. . The concentration of the toxic metals in the samples analysed ranged from 0.0006 to 0.01mg/L. The maximum contaminant level (MCL) for lead, cadmium, arsenic and chromium are 0.015ppm, 0.005ppm, 0.01 and 0.1 respectively. The concentrations of lead, chromium, arsenic and cadmium in the samples were lower than the MCL. All the samples contained the toxic metals though at low concentration. The water samples analysed contained low concentrations of the toxic metals which could accumulate in the body after some years. Toxic metals should be removed from drinking water from Water Corporations as much as possible to prevent their accumulation in the body.

Key words: Toxic metals, water, maximum contaminant level (MCL).

INTRODUCTION

Water is the most abundant chemical substance in the world. It covers about 10 percent of the surface of the earth. It occurs in form of water vapour in the atmosphere and this may collect as cloud and later come down to earth in the form of rain. It is also present below the earth.

Water is not only used for drinking, it is also used in greater quantities for washing, bleaching, dyeing, cooking, rising steam to drive engines or turbines to generate electricity and as a solvent in industrial processes[1,2,3].

Water is called the "universal solvent" because it dissolves more substances than any other liquid. This means that wherever water goes either through the ground or through our bodies it takes along valuable chemicals, minerals and nutrients.

Pure water has a neutral pH of about 7, which is neither acidic nor basic[4].

Water can be hard or soft, natural or modified, bottled or tapped, carbonated or still. About one-half of our water comes from underground water in tables and one-half from surface water in rivers, lakes and reservoirs[3,4].

Types of drinking water

Ordinary water contains some other substances as a result of it's affinity for them. Few people have tasted ideal pure water. We have natural and treated water. Natural water includes rainwater, river water, spring water, well water and seawater, while treated water is usually prepared for special purpose. Examples of treated water are distilled water, pipe-borne water for townships, and chlorinated water for use in swimming pools[4].

Metals in water supply may occur naturally or may be the result of contamination. Naturally occurring metals are dissolved in water when it comes into contact with rock or soil material other sources of metal contamination are corrosion of pipe and leakage from water disposal sites. Metals should be removed from drinking water if they are present at high enough levels to cause concern. Trace amount of metals are common in water, and these are normally not harmful to health. In fact some metals are essential to sustain life- calcium, magnesium, potassium and sodium must be present for normal body functions. Cobalt, copper, iron, manganese, molybdenum, selenium and zinc are needed at low levels as catalysts for enzymes activities. Drinking water containing high levels of these essential metals, or toxic metals such as alumina, arsenic, barium, cadmium, chromium, lead mercury, selenium and silver may be hazardous to health[2,5,6,7].

Heavy metals are elements having atomic weights between 63.546 and 200.590 and a specific gravity greater than 4.0 at least 5 times that of water. All heavy metals exist in surface waters in colloidal, particulate, and dissolved phases although dissolved concentrations are generally low. The colloidal and particulate metal may be found in hydroxide, oxide, silicate, or sulfide forms and also adsorbed to clay, silica or organic matter[8,9,10].

The soluble forms are generally ions or unionized organometallic chelates or complexes. The solubility of trace metals in surface water is predominately controlled by the water pH, the type and concentration of liquids on which the metal could adsorb, and the oxidation state of the min l components and the redox environment of the system[8].

Heavy metals in surface water systems can be from natural or anthropogenic sources currently natural inputs. Excess metal levels in surface water may pose a health risk to humans and to the environment[9].

Health effects of toxic metals

Ingestion of metals such as lead (Pb) cadmium (Cd), mercury (Hg), arsenic (As), barium (Ba), and chromium (Cr), may pose great risks to human health. Trace metals such as lead and cadmium will interfere with essential nutrients of similar oxidation states such as calcium (Ca^{2+}) and zinc (Zn^{2+}) [2,10,11,12,13].

The EPA has set maximum contaminant levels for metals including Arsenic (As) barium, cadmium, chromium, lead, copper, mercury, selenium, nickel[9].

Heavy metal poisoning is the toxic accumulation of heavy metals in the soft tissues of the body. Heavy metals may enter the body through food, water, or air or by absorption through the skin. When in the body, they compete with and displace essential minerals such as zinc, copper, magnesium, and calcium and interfere with organ system function.

Symptoms vary, depending on the nature and the quantity of the heavy metal ingested. Patients may complain of nausea, vomiting diarrhea, stomach pain, headache, sweating and a metallic taste in the mouth[2].

METHOD

Ten brands of sachet water, five samples of well water, five samples of tap water and five samples of table water were randomly selected for the research.

Determination of toxic metal ion concentration was carried out using the Atomic Absorption/ Flame Emission Spectrometry UNICAM MODEL 969, England.

Standard metal ion preparation

The calibration plot method described in the British pharmacopoeia, 2005, was used for the analysis[14].

Reference Standard metal ion of 0.05, 0.1, 0.15, 0.2, 0.25, and 0.3mg/L were prepared from the standard stock solution. The corresponding absorbances obtained were plotted against the concentration to give the calibration curve.

The absorbances of the water samples were obtained and the corresponding concentrations were derived from the regression equation.

RESULT

Table 1 showed the regression data obtained from the calibration plot of the standard Pb^{2+}, Cd^{2+}, As^{2+} and Cr^{2+} ions. The R2 obtained were 0.9999, 1.000, 0.9996, and 0.9941 for Pb^{2+}, Cd^{2+}, As^{2+} and Cr^{2+} respectively. This indicates that there was a good relationship between the absorbance and concentration of the reference metal solutions.

The concentration of the metal ions in the water samples analysed was obtained from the regression equation.

Table 2 showed the concentration of the metal ions in sachet water. The heavy metals were present in sachet water samples at low concentrations. The concentration of the metal ions in bottled water and tap water are shown in Table 3. Table 4 shows the concentration of the heavy metal ions in well water. Concentrations of the metal ions were lower than the maximum contaminant level (MCL) indicated for each metal ion by the EPA.

Table 1. Regression data obtained from the calibration plot of standard Pb^{2+}, Cd^{2+}, As^{2+} and Cr^{2+}.

Metalion	Pb^{2+}	Cd^{2+}	As^{2+}	Cr^{2+}
Regression equation	y = 0.94x+0.0004	y = 0.97x+0.0007	y = 0.954x-0.0035	y = 1.04x-0.006
R^2	0.9999	1.0000	0.9996	0.9941

Table 2. Concentration of toxic metal ions in sachet water (Sw) samples.

Sample	Pb^{2+}		Cd^{2+}		As^{2+}		Cr^{2+}	
	Absorbance	Concentration (mg/L)	Absorbance	Concentration (mg/L)	Absorbance	Concentration (mg/L)	Absorbance	Concentration (mg/L)
Sw1	0.004	0.003830	0.001	0.000278	0.003	0.006669	0.004	0.009615
Sw2	0.006	0.005957	0.003	0.002278	0.005	0.008669	0.005	0.010577
Sw3	0.001	0.000638	0.004	0.003278	0.003	0.006669	0.001	0.006731
Sw4	0.003	0.002766	0.003	0.002278	0.003	0.006669	0.003	0.008654
Sw5	0.005	0.004894	0.001	0.000278	0.004	0.007669	0.005	0.010577
Sw6	0.001	0.000638	0.003	0.002278	0.005	0.008669	0.001	0.006731
Sw7	0.003	0.002766	0.004	0.003278	0.005	0.008669	0.003	0.008654
Sw8	0.001	0.000638	0.005	0.004278	0.005	0.008669	0.001	0.006731
Sw9	0.002	0.001702	0.001	0.000278	0.002	0.005669	0.002	0.007692
Sw10	0.005	0.004894	0.001	0.000278	0.002	0.005669	0.005	0.010577

Table 3. Concentration of toxic metal ions in bottled table water (Bw) and tap water (Taw) samples.

Sample	Pb2+		Cd2+		As2+		Cr2+	
	Absorbance	Concentration (mg/L)	Absorbance	Concentration (mg/L)	Absorbance	Concentration (mg/L)	Absorbance	Concentration (mg/L)
Bw1	0.003	0.002766	0.001	0.000278	0.004	0.007669	0.003	0.008654
Bw2	0.001	0.000638	0.005	0.004278	0.002	0.005669	0.001	0.006731
Bw3	0.001	0.000638	0.003	0.002278	0.001	0.004669	0.001	0.006731
Bw4	0.004	0.003830	0.005	0.004278	0.004	0.007669	0.004	0.009615
Bw5	0.004	0.003830	0.002	0.001278	0.002	0.005669	0.004	0.009615
Taw1	0.004	0.003830	0.003	0.002278	0.003	0.006669	0.005	0.010577
Taw2	0.002	0.001702	0.005	0.004278	0.003	0.006669	0.002	0.007692
Taw3	0.005	0.004894	0.003	0.002278	0.003	0.006669	0.005	0.010577
Taw4	0.001	0.000638	0.001	0.000278	0.001	0.004669	0.001	0.006731
Taw5	0.003	0.002766	0.003	0.002278	0.004	0.007669	0.003	0.008654

Table 4. Concentration of toxic metal ions in well water (Ww)

Sample	Pb2+		Cd2+		As2+		Cr2+	
	Absorbance	Concentration (mg/L)	Absorbance	Concentration (mg/L)	Absorbance	Concentration (mg/L)	Absorbance	Concentration (mg/L)
Ww1	0.006	0.005957	0.001	0.000278	0.003	0.006669	0.006	0.011538
Ww2	0.001	0.000638	0.004	0.003278	0.004	0.007669	0.001	0.006731
Ww3	0.005	0.004894	0.002	0.001278	0.005	0.008669	0.005	0.010577
Ww4	0.003	0.002766	0.003	0.002278	0.004	0.007669	0.003	0.008654
Ww5	0.004	0.003830	0.003	0.002278	0.002	0.005669	0.004	0.009615

DISCUSSION

Toxic-metal contaminants found in water most especially ground water, are detrimental to human health and since human body cannot do without water[15], special attention should be paid to the analysis of water in our environment. The maximum contaminant level (MCL) is the maximum permissible level of a contaminant in water which is delivered to any user of a public water system. Each metal has a MCL indicated for it by the Environmental Protection Agency (EPA).

The maximum contaminant level for lead, cadmium, arsenic and chromium are 0.015ppm, 0.005ppm, 0.01ppm and 0.1ppm respectively[9,16]. The concentration of arsenic (As) obtained from each of the water sample was low compared to the Environmental Protection Agency (EPA) maximum contaminant level (MCL). The concentration of lead (Pb^{2+}) obtained from each water sample was lower than the MCL (0.015ppm) stipulated by Environmental Protection Agency[9]. Concentrations obtained for Cr^{2+} in all the samples were lower than the MCL (0.1ppm). The concentrations obtained for Cd^{2+} were low.

The water for drinking, tap water sachet water, bottled water and well water around us in Lagos contain the toxic metals, Pb^{2+}, Cr^{2+}, As^{2+} and Cd^{2+}, in concentrations lower than the maximum contaminant level, but, the problem at hand is the accumulation of the metals in the body after some years which could result into disease conditions (long term health hazards)[17,18]. Once in the body, the metals compete with and displace essential minerals such as zinc, copper, magnesium, and calcium, and interfere with organ system function.

Lead in high doses has been recognized for centuries as a cumulative general metabolic poison. Signs of the symptoms of acute poisoning are tiredness, lassitude, slight abdominal discomfort, instability, anaemia and in the case of children, behavioral changes[2].

Such symptoms are difficult to quantify and currently there is considerable interest in various possible subtle effects, including neurophysiological ones, caused perhaps by exposure to low levels of lead[1].

Acute poisoning of chromium may result in liver necrosis, nephritis and death in man due to uraemia. Lower doses will cause irritation of the gastrointestinal mucosa. Other health effects related to industrial exposure have been reported[2,19].

Acute poisoning by arsenic involves the central nervous system; leading to coma and death. The gastrointestinal tract, nervous system, the respiratory tract, and the skin can be severely affected[7].

Chronic arsenic poisoning could

manifest as general muscular weakness, loss of appetite and nausea leading to inflammation of the mucous membranes in the eye, nose and larynx; skin lesions may occur, neurological manifestations and even malignant tumors in organs may also be observed[6].

CONCLUSION

The concentrations of the toxic metal ions (lead, cadmium, arsenic and chromium) in domestic water samples analysed were lower than the MCL.

The general public should be informed about the harmful effect of these toxic metals (even at low concentrations) in water to human health if ingested since human body can not do without water.

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