Heavy metal contamination of drinking water in the city of Baiji

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Abstract

In order to ascertain water quality for human consumption and determined the sources of contamination, heavy metal were evaluated in the drinking water supplies to the city of Baji and its surrounding villages in Iraq. Standard methods were used for determining the concentration of some heavy metal such as Pb, Cd, Cu, and Zn in drinking water samples by atomic absorption spectrophotometer supplied with a carbon rode atomizer to increase the sensitivity. The results showed that the amount of lead present in the drinking water is too high and ranges from 0.06± 0.03 to 0.14± 0.02 ppm , cadmium value were from the below detection limit to 0.01 ppm, copper value were ranges from 0.21± 0.08 to 0.58± 0.04 and zinc value were ranges from 1.57 ±0.37 to 2.30±o.45.

Introduction

The widespread of contamination with heavy metal in the last decades has raised public and scientific interest due to their dangerous effects on human health This has led researchers to study the pollution with heavy metal in water and to determine their permissibility for human consumption[(1)].

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Heavy metals include lead, cadmium, cobalt, zinc, arsenic, mercury, silver, chromium, copper, iron, and platinum.

Heavy metals concentration in the water cannot be attributed to geological factors alone, but human activities do modify considerably the mineral composition of water. The recent population and industrial growth has led to increasing production of domestic, municipal and industrial wastes. Heavy metals are natural components and cannot be degraded or destroyed. To a small extent, they enter our bodies via food, drinking water and air (2).

Along with many other toxic compounds in the environment, a lot of heavy metals, or the metals with a very high density, are present in our immediate environment. These heavy metals may contaminate water supplies. The natural water analysis for physical, chemical properties including trace element contents are very important for public health studies.

Some heavy metals are essential to maintain the metabolism of the human body. but at higher concentrations they can lead to poisoning (3).

The presence of toxic metals in human bodies is highly significant for they are capable of causing serious health problems through interfering with normal biological function.

Some heavy metals have been reported to be of bio-importance to human and their limits in drinking waters have been reported and is presented in Table (1), and others like As, Cd, Pb, and methylated forms of Hg have been reported to have no known biological function in human and consumption even at very low concentrations can be toxic (4,5).

Even for those that have bio-importance, dietary intakes have to be maintained at regulatory limits, as excesses will result in poisoning or toxicity, which is evident by certain reported medical symptoms that are clinically diagnosable. Zinc is an element that balances copper in the body, and is essential for male reproductive activity. It serves as a co-factor for dehydrogenating enzymes and in carbonic anhydrase (4,5). Zinc deficiency causes anemia and retardation of growth and development. Magnesium is an important electrolytic constituent of the blood, present in the blood plasma and body fluids (6).

Heavy metal poisoning: The biotoxic effects of heavy metals refer to the harmful effects of heavy metals to the body when consumed above the bio-recommended limits. heavy metals disrupt metabolic function in two basic ways:

First, they accumulate and thereby disrupt function in vital organs and glands such as the heart, brain, kidneys, bone, liver, etc.

Second, they displace vital nutritional minerals from where they should be in the body to provide biological function.

Individual metals exhibit specific signs of their toxicity; the following have been reported as general signs associated with cadmium, lead, arsenic, and zinc poisoning.

Cadmium is toxic at extremely low levels. In humans, long term exposure results in renal dysfunction, characterized by tubular proteinuria. High exposure can lead to obstructive lung disease, cadmium pneumonitis, resulting from inhaled dusts and fumes. It is characterized by chest pain, cough with foamy and bloody sputum, and death of the lining of the lung tissues because of excessive accumulation of watery fluids. Cadmium is also associated with bone defects, viz; osteomalacia, osteoporosis and spontaneous fractures, increased blood pressure and myocardic dysfunctions (7).

Lead is the most significant toxin of the heavy metals, and the inorganic forms are absorbed through ingestion by food and water, and inhalation. A notably serious effect of lead toxicity is its teratogenic effect (8,9,10,11,12).

Lead poisoning also causes inhibition of the synthesis of hemoglobin; dysfunctions in the kidneys, joints and reproductive systems, cardiovascular system and acute and chronic damage to the central nervous system (CNS) and peripheral nervous system (PNS) (8).

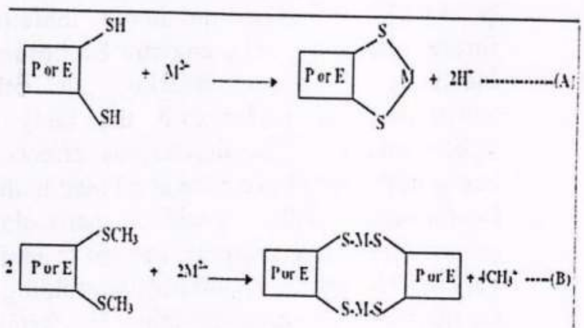
Lead affects children by leading to the poor development of the grey matter of the brain, thereby resulting in poor intelligence quotient. Its absorption in the body is enhanced by Ca and Zn deficiencies (2).

Zinc is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction The clinical signs of zinc toxicosis have been reported as vomiting, diarrhea (7).

Copper is an essential substance to human life, but in high doses it can cause anemia, liver and kidney damage, and stomach and intestinal irritation (9).

The poisoning effects of heavy metals are due to their interference with the normal metabolic processes, in the acid medium of the stomach, they are converted to their stable

oxidation states (Zn2+, Pb2+, Cd2+,Cu2+) and combine with the molecules such as proteins and enzymes to form strong and stable chemical bonds. The equations below show their reactions during bond formation with the sulphydryl groups of cysteine -SH and sulphur atoms of methionine –SCH3(10).



Where: P = protein; E = Enzyme; M = Metal

The hydrogen atoms or the metal groups are replaced by the poisoning metal and the enzyme is thus inhibited from functioning, whereas the protein–metal compound acts as a substrate and reacts with a metabolic enzyme. In equation shown below, enzymes (E) react with substrates (S) , a substrate fits into an enzyme in a highly specific fashion, due to enzyme chirality's, to form an enzyme–substrate complex (E-S*) as follows (11).

$$\mathbf{E + S \rightarrow\rightarrow E\text{-}S \rightarrow\rightarrow E - S^* \rightarrow\rightarrow E - P \rightarrow\rightarrow E + P}$$

(E = Enzyme, S = Substrate, P = Product, * = Activated Complex)

While at the E-S, E–S* and E-P states, an enzyme cannot accommodate any other substrate until it is freed. Sometimes, the enzymes for an entire sequence coexist together in one multi-enzyme complex consisting of three or four enzymes. The product from one enzyme reacts with a second enzyme in a chain process, with the last enzyme yielding the final product as follows:

E1 E2 E3

E4

A →→→ **B**→→→

C→→→ **D**→→→ **F**

(E1 to E4 are enzyme)

The final product F goes back to react with the first enzyme thereby inhibiting further reaction . The enzyme E1 becomes incapable of accommodating any other substrate until F leaves the body by utilization (12). The deleterious effects of heavy metal ions have been attributed to their interactions with specific, particularly susceptible native proteins. Proved to inhibit very efficiently the spontaneous refolding of chemically denatured proteins by forming high-affinity complexes with thiol and other functional groups.

Therefore, the metal remains embedded in the tissue as metallo-enzyme and can be conveniently replaced by another metal ion of similar size. Thus Cd2+ can replace Zn2+ in some dehydrogenating enzymes, leading to cadmium toxicity. In the process of inhibition, the structure of a protein molecule can be mutilated to a bio-inactive form, and enzyme can be completely destroyed (10).

The most toxic forms of these metals in their ionic species are the most stable oxidation states. Where in their most stable oxidation states, they form very stable biotoxic compounds. As will as heavy metals in the body multiply free radicals chain reactions several thousands, possibly several million times. Free radicals are increased in activity and quantity by bumping into toxic metals in the body. Thus, toxic metals are a cause of free radicals. Free radicals processes contribute to the uncontrolled chain reaction cause several damages with in the cells (13).

Material and method

De-ionized distilled water bottles from five station in baji and village around baji , in Dec. 2007. One liter of each water sample was taken in duplicate at two deferent sampling periods approximately one month a part. The samples were obtained directly from the water pump after allowing the water to rum at least 20 minutes. These samples were analyzed by flameless atomic absorption spectrometry in triplicate

To determine lead, cadmium, zinc and copper. A standard solution for each element under investigation was prepared and used for calibration.

The drinking water samples were collected in pre-washed with doubly

Result and discussion

The contents of Pb, Cd, Co and Zn in different water samples from different water stations presented in Table 2. The values of metal concentrations were compared with the maximum permissible concentration of WHO 1984.

All water samples contained higher concentrations of lead than that recommended by WHO 1984. The lowest and highest values were in station 4 and 2 respectively, this high level of lead might be due to release a large amount of petrol due to several explosions of main pipe line close to the city of baji , the waste product of baji refineries and baji power station these waste product release directly to the river stream with out any treatment. In addition to that some station still using lead pipe which increase the level of lead.

A major source of environmental Pb, particularly in urban areas, is due to the combustion of leaded petrol. Lead is discharged by vehicles into air, then adsorbed from the air by environmental samples such as soil and plant than inter the waterways from soil.

As shown in Table 2, the concentrations of cadmium of all the samples under investigation were under the maximum permissible concentration of cadmium (FAO/WHO 1984).

This study show that the zinc content in water samples were in the range of 1.57 to 2.30 ppm The lowest and highest values were in station 1 and 3 respectively, and they less than the maximum limit allowed of zinc for drinking water. Also there are some variations between stations.

Copper concentrations in the drinking water samples were in the range of 0.21-0.58 ppm The lowest and highest values were in station 4 and 5 respectively, but even in Station 5 Cu was considerably below the limit of 1.0 mg/l permitted by WHO in drinking water.

Although heavy metals cannot be avoided due to their prevalence in the environment, several measures besides avoidance of the source of heavy metals can be taken to treat toxicity. Diet, nutritional supplements and chelating agents such as DMSA are safe and effective means to reduce heavy metal toxicity.

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Table (1): Guideline in drinking water by the World Health Organization (WHO) and National Agency for Food and Drugs Administration and Control (NAFDAC), Nigeria.

Heavy metal	Max. acceptable conc. (WHO)	Max. acceptable conc. (NAFDAC)
Lead	0.01 mg/L	0.0 mg/L
Cadmium	0.003 mg/L	0.0 mg/L
Zinc	5.0 mg/L	5 mg/L
copper	1.0 mg/L	1.0 mg/L

Table (2): Concentration (p.p.m) of heavy metal in fresh tab water

Heavy metals	Fresh tap water Mean ± SD	Permissible limit of metal in water (p.p.m) (WHO 1984)
Lead		0.015
Cadmium		0.01
Zinc		5.0
Copper		1.0

Table (3): The concentration of heavy metal in different water samples.

Station no.	Lead Pd	Cadmium Cd	Zinc Zn	Copper Cu
Station 1	0.12 ± 0.04	0.01	1.57 ± 0.37	0.38 ± 0.09
Station 2	0.14 ± 0.02	0.00	1.80 ± 0.21	0.32 ± 0.12
Station 3	0.08 ± 0.02	0.00	2.30 ± 0.45	0.43 ± 0.9
Station 4	0.06 ± 0.03	0.01	2.10 ± 0.18	0.21 ± 0.08
Station 5	0.13 ± 0.06	0.00	1.65 ± 0.32	0.58 ± 0.04