Determination of toxic metals in salt deposits in Bormanda, Nigeria

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ABSTRACT

Heavy metals which may co-exist with soil salt, when present above their threshold levels could be hazardous to the body system. Common salt samples extracted from soil samples from Bormanda and Karim Lamido Local Government Areas in Taraba State, Nigeria, were digested in aqua-regia and analysed for Lead, Cadmium, Chromium, Arsenic and Nickel using Atomic Absorption Spectrophotometry. The mean concentrations (mg/kg) of Lead (0.470±0.005) and Cadmium (0.040±0.001) were higher than the threshold levels recommended by World Health Organisation. However, the level of Nickel (0.140±0.003 mg/kg) was within the threshold limit. Chromium and Arsenic were not detected in any salt sample. The results revealed the occurrence of some toxic metals in association with the soil salt deposits. Works on selective removal of the heavy metals is therefore suggested to isolate the toxic metals from the soil salt samples.

INTRODUCTION

Some soils in Bormanda, a village in Karim Lamido LGA of Taraba State are associated with edible salt that may be contaminated by heavy metals. The village is endowed with an extensive deposit of halite. The Bormanda community has been involved in the local mining and processing of soil salt for the generation of personal income through the informal business activities at the soil salt deposits. Since this salt originated from the earth crust, its association with heavy metals is a possibility. Heavy metals are highly toxic and can cause damaging effect even at low concentrations[1]. They tend to accumulate in the food chain and in the body and may be stored in kidney. They bind to negatively charged organic molecules to form complexes. Some of the heavy metals and other metals when present in high concentration in the body system could result in ill health and consequently leads to death if adequate measures are not taken to check the accumulation[2]. The degree to which organ tissues or cells is affected by a heavy metal toxin depends on the toxin itself and the individual's degree of exposure to the toxin. The metals affect an individual in such a way that its respective accumulation within the body leads to a decline in the mental cognitive and physical health of the individual[3].

Heavy metals overload in the walls of coronary arteries seems to decrease levels of nitric oxide, a compound known as "Endothelial Relaxing Factor", without which normal blood flow is impeded and therefore increases the risk of vascular blockage[2,3]. Heavy metal overload in the adrenal glands reduces the production of hormones and may cause early aging, stress, decreases sex drive and aggravation of menopausal symptoms. Heavy metal overload may also lead to neurological diseases such as depression and loss of thinking power. It has the potential to aggravate conditions such as osteoporosis and hypothyroidism. For obvious reasons, removing metals from the body safely has been a concern of physicians for many years[4].

In general, heavy metals are systemic toxins with specific neurotoxic, nephrotoxic, fetotoxic and teratogenic effects. Systems in which toxic metal elements can induce impairment and dysfunction include the blood and cardiovascular, eliminative pathways (colon, liver, kidney, skin), endocrine (hormonal), energy production pathways, enzymatic, gastrointestinal, immune, nervous (central and peripheral), reproductive and urinary[5].

Lead affects the red blood cells (anemia and other effects on the hemopoietic system are the common effects) and causes damage to organs including the liver, kidneys, heart and male gonads as well as causes effects to the immune system. In the central nervous system, lead causes edema, and its effects are often irreversible. Reduced IQ, learning behavioral difficulties has been reported even with low blood lead levels[2]. Lead presents a reproductive hazard in several ways. It is gonatoxic and caused a reduction in pregnancies in successfully mated mice and is embrotoxic. Exposure to lead is more dangerous for young and unborn children. Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, and decreased mental ability in the infant, learning difficulties and reduced growth in young children. These effects are more common after exposure to high levels of lead. It can cause abortion and damage the male reproductive system Environmental Protection Agency (EPA) limit in air is not to exceed 1.5 $\mu g/m^3$ average over 3 months. EPA limit in drinking water is 15µg/liter. OSHA limit in workroom air is $50\mu g/m^3$ for an 8- hour work day[6,7].

Eating food or drinking water with very high levels (metal and compound) increases salivation severely irritates the stomach, leading to vomiting and diarrhea. Skin contact with cadmium is not known to cause health effect in human or animals. Long term exposure to low level of cadmium in air, food or water leads to build up of cadmium in the kidneys and possible kidney disease[8,9,10]. Other potential long term effects are lung damage and fragile bones, abdominal pain, choking and tenismus. Environmental Protection Agency (EPA), drinking water limit is 5ppb. EPA also limits how much cadmium can enter lakes, rivers, waste and cropland and forbids cadmium in pesticides.

Chromium is an essential nutrients required for normal sugar and fat metabolism and works primarily by potentiating the action of insulin. It is present in the entire body but with the highest concentration in liver, kidneys, spleen, and bone. Although chromium is only required in very small amount our modern day diet has left

many people short of chromium on a daily basis, with the average American being chromium deficient, and two out of three being hyperglycemic, pre-hyperglycemic or diabetic. Chromium is needed for energy, maintains stable sugar levels. In cooperation with other substances it controls insulin as well as certain enzymes. A shortage of chromium may also lead to anxiety, fatigue, and glucose intolerance (particularly in people with diabetes). Inadequate metabolism of amino acids and an increased risk of arteriosdeopsis have also been reported. Heavy metal overload can lead to unresponsiveness of diabetics to their medications[11].

Arsenic is found in nature at low levels. It's mostly in compound with oxygen, chlorine, and sulfur (inorganic arsenic compound). Arsenic in plant and animals combines with carbon and hydrogen compounds (organic arsenic). Organic arsenic is usually less harmful than inorganic arsenic. Most arsenic compounds have no smell or special taste. Inorganic arsenic compounds are mainly used to preserve wood. EPA drinking water limit is 0.05ppm. Chronic toxic effect are fatigue, loss of energy, nasal septum perforation, ulceration in folds of skin, increase in pigmentation of skin, appearance of small "corns" or "warts" on the palms, soles, and torso, exfoliative dermatitis, rashes, muscular paralyses and atrophy, sensory disturbances, visual disturbance and blindness, liver cirrhosis and kidney [2,3,4]

The most common adverse health effect of nickel in human is an allergic reaction. The most common reaction is skin rash at the site of contact. Acute toxic effects occur in two stages, immediate and delayed headache, dizziness, shortness of breath, vomiting and nausea. The initial symptoms of over exposure, the delay effects (10 to 36 hours) consist of chest pain, coughing, shortness of breath, bluish discoloration of the skin and in severe cases convulsion and death. Measurement of the amount of nickel in blood, feces and urine can be used to estimate exposure to nickel[4,5,7,8]

The main objective of this study is to determine the heavy metal concentrations in the soil salt samples from Bormanda.

MATERIALS AND METHODS

Soil samples were collected from the mining site in Bormanda, Taraba State and stored in a polythene bag for analysis.

Extraction of salt from the soil

250g of the soil sample was weighed with the aid of a weighing balance and then poured into a 500ml beaker. 250ml of water was added to the soil sample in the beaker and was stirred to ensure proper dissolution of the salt from the soil. The mixture was filtered as described by Block, 2003. The filtrate was carefully evaporated on a hot plate at 100^{o}C and allowed to cool after which the salt crystals were collected.

Digestion of salt sample

3g of the crystallized salt was weighed into a 250ml beaker and a mixture of 30ml concentrated HCl + 10ml concentrated HNO_3 (aqua regia) was added to the salt crystals in the beaker. The beaker with the mixture was carefully placed on a hot plate in a fume cupboard and allowed to boil to dryness. 50ml

of hot de-ionised water was added to the residue in the beaker and was filtered into 100ml volumetric flask. The residue on the filter paper was washed with warm de-ionised water until the filtrate reached the mark on the volumetric flask. The filtrate was transferred into a sample bottle and was used for determination of toxic metal with Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The concentrations of the toxic heavy metals in the salt samples are shown in Table 1. The mean concentrations of Lead, Cadmium and Nickel were 0.470±0.005, 0.040±0.001 and 0.140±0.003 mg/kg respectively. The lead and cadmium values were higher than the threshold levels recommended by World Health Organization. A gradual build up of these toxins will occur, if heavy metals enter and accumulate in body tissue faster than the body's detoxification pathways can dispose them off. High concentration exposure is not necessary to produce a state of toxicity in the body tissues and over time it can reach toxic concentration levels[3,12,13,14,15,16]. Chromium and Arsenic were not detected in any salt sample. Generally, the results of this study revealed the occurrence of some toxic metals in association with the soil salt deposits. Therefore, it is important to undertake Hazard Analysis and Critical Control Point (HACCP) studies to identify and integrate critical control measures into strategies for improving the safety of the soil salt product from the local salt mining site and avoid the metal related health hazards already described in various reports[12,17,18,19,20,21,22].

Table 1: Concentrations (mg/kg) of toxic heavy metals in the salt samples

Element	**Concentration (mg/kg) ±SD**	**NIS Standard (2007) (mg/kg)**
Lead	0.470±0.005	0.010
Cadmium	0.040±0.001	0.003
Chromium	Not detected	0.050
Arsenic	Not detected	0.010
Nickel	0.140±0.003	0.020

CONCLUSION

The results of this study have shown that the extracted common salt from the soil salt deposits in Bormanda, Karim Lamido LGA, Taraba State is associated with heavy metals in concentrations above their threshold levels. Consumption of the locally processed salt has the potential to bio-accumulate toxic metals and present health hazards. Selective removal of the heavy metals is therefore suggested to isolate the toxic metals from the soil salt samples. This is expected to improve the economic value of common salt derivable from the deposit.

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