ELIMINATING THE HEALTH RISKS OF HEAVY METALS IN DRINKING WATER

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Abstract

The threat to human health caused by contamination of drinking water sources by heavy metals like lead, silver, mercury, arsenic, cadmium, chromium, nickel etc generated by human activities and natural causes is enormous. This paper discusses the quality of drinking water, the health risks of heavy metal contaminated water, their sources, some selected methods of treatment which include Reverse Osmosis and Ultra Filtration and recommended concerted awareness and stiff punishment for those that contaminate water.

Introduction

Water is the most abundant liquid on earth, it is undoubtedly the most precious natural resource that exists on the planet. It covers three-quarters of the earth surface (Musa, Yakasai & Ya'u, 2008). Human activities and settlements hinge on the availability of water. Water forms the essential medium in which the chemical reactions of human cells proceed. It holds and helps transport the electrically charged ions that generate nerve signals (Ademoroti, 1996).

The human body is estimated to contain about 60-70 percent water. Blood composition is mostly water, muscles, lungs and brain all contain a lot of water (Lenntech, 2004). Water is used by the body to regulate its temperature and provide the means for nutrients to travel to all body organs. Water also transports oxygen to cells, removes wastes, protects joints and organs.

The Standard Organization of Nigeria (2007) defines drinking water as all water in its original state or after treatment intended for drinking, cooking, food preparation or other domestic purposes, regardless of its origin and whether it is supplied from a drinking water system, a tanker or taken from a private well. Drinking water needs to be safe for human consumption and other uses. But increase population growth, industrialization and agricultural activities had led to an increase in the amount of waste generated which end up in water ways (Dike, Ezealor & Oniye, 2004). The above mentioned factors and geological activities like mining make water around these areas unsafe for drinking and a potential cause of disease and illness due to the presence of heavy metals in this water. Heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations (Lenntech, 2004). Toxicity levels depend on the type of metal, its biological role and type of organisms that are exposed to it (Lenntech, 2006). The heavy metals linked most often to human poisoning are lead, mercury, arsenic and cadmium. Other heavy metals including copper and zinc are actually required by the body in small amounts but can also be toxic in large doses (European Public Health Alliance, 2008).

Sources of Heavy Metals in Drinking Water

Heavy metals in the environment may be caused by air emissions from coal-burning plants, smelters, and industrial facilities: waste incinerators, process wastes from industries, and lead in household plumbing and old house paints (Ademoroti, 1996). Apart from those generated as wastes from industrial and human activities, heavy metals exist as natural components of the Earth's crust (Lenntech, 2004). Heavy metals can also enter the environment through natural processes, for example, naturally occurring geologic deposits of arsenic can dissolve into ground water, potentially resulting in unsafe levels of this heavy metal in drinking water supply in the area.

Once released into the environment, heavy metals can remain for decades or centuries increasing the likelihood of human exposure since they cannot be degraded or destroyed. Ademoroti (1996) asserted that pollution of streams and rivers flowing through areas where fungicide and pesticides have been applied and industrial districts where there may have been metal waste deposits present varied and difficult problems due to drainage into our different water bodies. Mining activity is also one of the major contributors to heavy metal pollution. Land and water bodies around the area are usually polluted from these activities. Acid rain breaks down soils and releases heavy metals into streams, lakes, rivers and ground water (Lenntech, 2004). Metals are commonly used in manufacturing plants and technical facilities. Production processes for metal finishing, transportation (automotive, aviation, rail road), electronics, telecoms and mechanical parts fabrication industries consume vast quantities of heavy metals and metals containing chemicals every day. Their wastes when released into water streams often contain toxic metals, and other contaminants.

Health Effects of Heavy Metals on Humans

Heavy metals can be very harmful to health if found in drinking water. They penetrate and pollute natural water sources making people ill and as well, exposing them to long term health consequences and terminal illness. Severe effect include reduced growth and development, cancer, organ damage, nervous system damage, and in extreme cases, death (Abdulhamid, 2005). Exposure to some metals, such as mercury and lead may cause development of autoimmunity, in which a person's immune system attacks its own cells. They can lead to joint diseases such as rheumatoid arthritis, and diseases of the kidney, circulatory system and nervous system (European Public Health Alliance, 2008).

The Table I: World Health Organisation's tolerable limit for selected heavy metals.

Metal	Unit	Maximum Permitted	Health impact
Arsenic (As)	Mg/L	0.01	Cancer
Cadmium (Cd)	Mg/L	0.003	Toxic to the kidney
Lead (Pb)	Mg/L	0.01	Cancer, interference with Vitamin D metabolism, affect mental development in infants, toxic to the central peripheral nervous systems
Chromium(Cr)	Mg/L	0.05	
Mercury(Hg)	Mg/L	0.001	Cancer
Nickel(Ni)	Mg/L	0.02	Affects the kidney and central nervous system
			Possible carcinogenic

Sources: Standards Organisation of Nigeria, 2007

The young are more prone to the toxic effects of heavy metals, as the rapidly developing body systems in the fetus, infants and young children are far more sensitive and prone to infection by heavy metals. Childhood exposure to some metals can result in learning difficulties, memory impairment and behavioral problems such as aggressiveness and hypersensitivity (Lenntech, 2006). At higher doses heavy metals can cause irreversible brain damage.

Removing Heavy Metal from Drinking Water

Availability of clean and safe drinking water enhance the health status of a people, improve financial status as less money is spent on treating water borne or related diseases.

Considering the importance of having available clean and safe drinking water, it becomes necessary to explore all possible ways of eliminating heavy metals from drinking water, especially domestically. Boiling of water will not remove heavy metals and could slightly increase their concentration if boiling continues and large amount of water is lost as steam. Chlorine (bleach) disinfectant will not remove heavy metals from water (Ademoroti, 1996).

Most methods for removal of metals are based on sedimentation, filtration or chemical treatment. Solubility of different metals varies with the pH of waste stream. Some efficient methods of eliminating heavy metals from drinking water are discussed below.

Ultra Filtration (UF)

Metal solubility varies with the pH of the solution. At a pH of 10, for example, most heavy metals have concentrations of 1.0milligram per liter (mg/l) or less than one parts per million(ppm) in the insoluble or precipitated state, the metal particle size is 0.1 micron or larger (greater than 0.1 micron). An ultra filtration (UF) membrane has submicroscopic pore size of less than 0.01 micron and thus will retain the metal precipitate. Cross flow ultra filtration is a pressure-driven filtration process in which the process liquid flows parallel to the membrane surface. Under a pressure of 10pounds per square inch (psi) to 100 psi, the filtrate passes through the membrane and exits as clear permeate. The rejected species are retained and collected for disposal. The membrane's performance is measured by the permeate flux and the rejection of the constituent metals (Remco, 2007).

The ultra filtration membrane pores are asymmetrical and shaped like inverted cones, with smaller diameters on the feed side and larger diameters on the permeate side. Since any particle that passes through a pore continues unimpeded without accumulating within the membrane, ultra filtration membrane pores do not plug. Cleaning of these filters is thus easy and inexpensive and routine cleaning allows for repeated use over long period of time. With proper operation and maintenance, ultrafiltration membranes will operate for several years without replacement.

The most common membranes are based on durable polyacrylonitrile (PAN). These materials are suitable for continuous processing cycles and are cleaned with acid, caustic and/or surfactants. Membrane life expectancy (normally 3-5years) is depended on the process conditions and the cleaning frequency.

Membranes are usually packed into tubular, spiral and hollow fibre configurations. The most significant difference among the three is the characteristics of the flow channel. Tubular membranes are open channel designs, ranging from 0.25inch to 1 inch in diameter, which accommodate water with large particles, high viscosity and/or high concentrations of suspended solids. Tubular membranes process such liquids without extensive prefiltration, spiral modules have a thin, tortuous flow channel, ranging from 0.020inch to 0.10inch in height. The flow channels is constructed of porous netting placed between adjacent layers of flat membrane sheets. The materials are combined with permeate carrier and adhesive, then wound into a cylindrical shape. The feed liquid passes over the netting and membrane. Permeate collects on the low pressure side of adjacent membrane sheets and travels to the central collection tube (Lenntech, 2007). Hollow fiber membranes are made by extruding polymers into the shape of a tube. The flow channel diameter ranges from 0.02inch to 0.10inch. Compared to spirals and hollow fibers, hollow fibre membrane are more resistant to channel plugging. Hollow fiber may be back pulsed or subjected to reverse flow conditions to achieve optimum removal of contaminants (Remco, 2007).

Reverse Osmosis (R.O)

Reverse Osmosis is one of the finest methods of water filtration. This process allow the removal of all particles as small as ions from a solution. It is used to purify water and remove salts and other impurities in order to improve the colour, taste or properties of water. Reverse Osmosis uses a membrane that is semi-permeable, allowing the fluid that is being purified to pass through it while rejecting other ions and contaminants from passing (Remco, 2007). This technology uses a process known as cross flow to allow the Reverse Osmosis membrane to continually clean itself. This is why Reverse Osmosis element can last for many years before clogging or needing replacement. In constructing Reverse Osmosis module the long sheets of semi-permeable membrane with pores of about 0.0001 micron are ingeniously sandwiched together and rolled up around a hollow central tube in a spiral fashion. The membrane is put in to a container (membrane housing) so pressure can be maintained on its surface. It is this pressure that supplies energy to force the water through the membrane (Free Drinking Water, 2006). The higher the pressure, the larger the driving force and efficiency. Typically, a module for home water treatment is as small as two inch diameter and ten inch long.

Recommendation

Considering the negative health impact of heavy metals in drinking water and the need for their removal, the following recommendations are made:

* The general public should be sensitized on the consequences of collecting drinking water near areas of geological activities.
* Punishment for industries that dump solid wastes into water bodies used as source of drinking water should be enforced.
* The government should subsidize the cost of domestic water treatment devices especially those that reduce the concentration of heavy metals in water and give grants to relevant research institutions for research and development of new methods.
* Just as the government gives treated mosquito nets and antimaleria drugs free to individuals, Reverse Osmosis and ultrafiltration devices should be given to communities especially in rural areas who are vulnerable to the danger of heavy metals in drinking water and should be trained on how to use the devices.
* Legislations regulating mining activities should be enforced.

Conclusion

Clean and safe drinking water will enhance the health status of any nation. Eliminating heavy metals from drinking water, regardless of the water source is achieveable when appropriate methods are used. Reverse Osmosis and ultra filtration as methods of filtration, have the advantage of lasting for a long time without loosing their efficiency and ability to remove heavy metals from drinking water.

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