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Effect on Human Health due to Drinking Water Contaminated with Heavy Metals

Malik QA* and Khan MS

Punjab University, College of Earth and Environmental Sciences, Lahore, Pakistan

Abstract

Due to industrialization and environmental effects the drinking water quality has been greatly affected in Pakistan. A number of industries are draining their waste containing heavy metals without any treatment in effluents. As a result of this practice almost all of the fresh water resources are getting contaminated, although the deep aquifer in most of the countries is still safe from contamination of heavy metals. In drinking water, presence of heavy metals is threat to human health. People exposed to heavy metals through water consumption are vulnerable to cancer and other risks. This research aims at reviewing the presence of heavy metals in drinking water and their possible health effects.

Keywords: Water contamination; Drinking water; Heavy metals; Human health

Introduction

In Pakistan access to safe drinking water has become a great problem due to increase in population, the local population is forced to shift their residence in newly established colonies under private sector management. In most of the cases there are no water supplies and as a result the local population has to depend on shallow aquifers by installing hand pumps or installing electric motors to fetch their water needs. Mostly these new settlements are located around industrial zones. Hence they are at high risk by the effect of heavy metals due to contaminated water consumption.

Supply of safe drinking water is crucial to human life and safe drinking water should not impose a significant risk to humans [1]. Although a few heavy metals are essential for human health, an excess amount of these metals can have negative effects [2]. Heavy metals are released into the environment through natural process and anthropogenic activities.

Industrial processes generate wastes, which are mostly discharged into the environment. Industrial activities, especially electroplating, metal smelting and chemical industries and manufacturing processes are sources of anthropogenic heavy metals in water. Poorly treated domestic, industrial and agricultural wastewater contains high concentrations of metals, which are often discharged into the environment. Some heavy metals, such as mercury and lead, may also enter the atmosphere due to traffic pollution and industrial activities, which can be deposited in soils around the reservoir and then enter the water along with the surface runoff [3]. The sources of drinking water e.g., surface waters, ground water and sea water are likely to be polluted by heavy metals [4]. Leaching of metals from water distribution system (WDS) can contaminate drinking water. Although metals are removed during desalination of seawater, desalinated drinking water might contain various metals, possibly due to treatment and stabilization, blending with treated groundwater and leaching of metals from pipes of the WDS [5].

A number of heavy metals can induce cancer (e.g., inorganic arsenic and/or non-cancer e.g., Hg risks in humans) [2,6]. Studies have reported various chronic and sub chronic effects from exposure to heavy metals. Past studies report heavy metals in drinking water, including their types and quantities, factors affecting metal concentrations, sources, human exposure, risk and removal. Despite significant progress, research is needed to ensure safe drinking water. Small and rural communities and individuals often consume water with a higher level of heavy metals than the guideline values [1].

To date, removal of all heavy metals from drinking water with a comprehensive technique has not been reported. Further populations are exposed to drinking water from taps inside the building, where the metal concentrations increase due to stagnation of water in the water distribution system, cooler hot water tanks (HWTs) and plumbing pipes (PP) inside the building. This review focuses on human exposure and risks because of heavy metals in water.

Human exposure and risks

Thirty five metals pose a threat to human health, 23 of which are heavy metals [7]. Studies report various effects of heavy metals in drinking water [2,8]. According to the International Agency for Research on Cancer (IARC), inorganic As and Cd are classified as human carcinogens [9]. As is related to cancer risk and skin damage, Cd is linked to kidney damage and cancer. Other effects such as heart diseases and blood cholesterol from Sb, Anemia from Pb, kidney and liver damage from Hg, and gastrointestinal disorder from Cu are also reported [2,8].

Among the heavy metals As, Cd, Pb, Cr, Cu, Hg and Ni are of major concern, mainly due to their presence at relatively high concentrations in drinking water and their effects on human health [8]. Among the heavy metals, As, Cd and Pb have extensively been studied for their public health effects [2,8].

Smith et al. [10] reported that drinking 1 L/day water with As of 50 µg/L over one's life time could lead to cancer of the liver, lung, kidney or bladder in 13 per 1000 persons. Another study reports an

***Corresponding author:** Malik QA, Punjab University, College of Earth and Environmental Sciences, Lahore, Pakistan, Tel: +00924235437595; +03344399768; E-mail: malikqh@hotmail.com

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increased occurrence of skin lesions from As dose of 0.0012 mg/kg/day through drinking water [11]. Arain et al. [12] reports moderate correlation between As in drinking water and respiratory disorders. As was reported to be detrimental to the central nervous system and cognitive development in children [13]. It was also found to accumulate in fingernails and hair [14].

Sub-chronic effects, such as the risk of still births, were increased by six fold in women who consumed drinking water with As ≥ 200 μg/L during pregnancy [15]. As in drinking water is one of the major issues in more than 30 countries [16]. Next to As, Pb was most investigated in the context of its public health effects. Pb can affect the central nervous, renal, hematopoietic, cardiovascular, gastrointestinal, musculoskeletal, endocrinological, reproductive, neurological, developmental and immunological systems [8] although significant fractions of Pb could be attributed to drinking water other sources such as Pb paint, dust and leaded gas could be the important sources of Pb [8]. The third most frequently reported heavy metal in drinking water is Cd, and it has been identified as a public health concern [2,8,17,18]. Cd contaminated drinking water is also linked to chronic renal failure [8,19]. Gobe and Crane [20] reported kidney failure due to long term exposure to Cd. Chronic exposure to Cd could lead to anemia, anosmia (loss of sense of smell), cardiovascular diseases, renal problems, osteoporosis and hypertension [8]. Cd can cause both acute and chronic intoxications [21]. It is highly toxic to the kidney. Upon long exposure at low concentrations, it could become deposited in the kidney, ultimately leading to kidney disease, fragile bones and lung damage [22]. Experiments on animals show that 50% of Cd absorbed in the lungs [23]. Henson and Chedrese [24] report the association of Cd exposure during pregnancy with premature birth and reduced birth weights.

Removal of heavy metals from drinking water

Removal of heavy metals is an important step towards safe drinking water. Adsorption was found to be the method of choice with various adsorbents being available for this purpose. The other methods included chemical precipitation, physical separation, ion exchange, membrane filtration, membrane distillation and hybrid methods [1,25].

Future Research Needs

In past, effects of consuming heavy metal contaminated drinking water were characterized and technologies were developed to remove metals from drinking water. To ensure that public health is better protected, future study is needed to address the following issues. Co-exposure to multiple heavy metals can have synergistic or antigonistic effects on human health. As in ground water has become a global issue. In many cases, the co-presence of As, Mn and Sb in drinking water has been reported. Co-exposure of As with other heavy metals (e.g., Sb and Mn) must be better characterized in the context of the effects on human health. Regulatory agencies may link the maximum limits of a metal in drinking water to the co-exposure scenarios as well as other factors e.g., epidemiological and toxicological effects, treatability, etc.

Conclusion

It is concluded that, given the presence of industrial activity that can release heavy metals into the environment, Pakistan may be at high risk of metal contamination. Sampling and analysis activities are needed to confirm this at site-specific locations where heavy metals have likely been released to ensure that drinking water supplies are safe for human consumption.

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