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Monitoring the Arsenic Concentration in Groundwater Resources, Case Study: Ghezel ozan Water Basin, Kurdistan, Iran

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Water resource contamination is one of the major challenges in the way of sustainable development. Arsenic is a dangerous contaminant with adverse effects on human health and is highly restricted by international environmental standards. An unofficial reports indicated the presence of compounds of arsenic in groundwater of rural areas in Ghorveh and Bijar counties of Kurdistan province. The reports noted contamination within the boundaries of the Ghezel ozan water basin in western Iran. These reports caused serious concerns for the residents of these areas. Accordingly, water sampling was done during the summer of 2004 from areas where arsenic contamination was suspected. Nine villages in Bijar and 13 villages in Ghorveh County were considered for water sampling. The arsenic concentration in all water samples was higher than the US EPA maximum contaminant level (50 ppb). Continual droughts in the area have caused local water tables to drop dramatically. Consequently, there has been an increased rate of oxidation in arsenic containing minerals causing arsenic ions (As^{3+} and As^{5+}) to enter the liquid phase. By considering relatively high amount of annual precipitation in the region, particularly in cold season, a sophisticated method in gathering, maintenance and use of groundwater may be considered for at least a limited period of the year. Furthermore, controlled use of surface water rather than groundwater may lessen arsenic contamination risk.

Key Words: Arsenic, Groundwater, Ghezel ozan water basin, Kurdistan, Iran.

INTRODUCTION

Arsenic is a highly toxic contaminant with adverse effects on human health. Safe concentrations of arsenic in drinking water are extremely restricted by international environmental standards. Arsenic occurs naturally and is widely distributed in natural systems. Release from arsenic-enriched minerals is the primary source of arsenic in the environment[1,2]. The main anthropogenic sources include mining and smelting, industrial processes and agricultural practices[1,2]. Simultaneous air and groundwater pollution by arsenic, causes serious health diseases over large areas of southern China[3,4] and Inner Mongolia[5,6].

Highly arsenic contaminated (> 50 µg/L) groundwater has been reported in various parts of the world, including Argentina, Bangladesh, Chile, China, Hungary, West Bengal (India), Mexico, Taiwan, Vietnam and many parts of the USA[6]. Large scale arsenic contamination occasionally appears in recent sediments and the regions most affected by arsenicosis are the modern Ganges Delta area of West Bengal, India, and Bangladesh[7-10].

Water resources contamination is one of the major challenges in the way of sustainable development. Such contamination is even more likely in places where extreme drought is coupled with excessive usage. Iran is among the countries that are highly exposed to this threat.

Area of study: Kurdistan province is located in western Iran between 34°44' and 36°30' north latitude and 45°31' and 48°16' east longitude. It occupies *ca.* 28,203 square kilometers or 1.71 % of Iran's total area. About 1,350,000 people live in Kurdistan, comprising about (around 2 percent of Iran's total population). Approximately 641000 people live in rural areas according to the national census in 1995. Located on the east side of the province, Ghezel ozan water basin occupies 7836.1 square kilometers. Ghorveh and Bijar with population of 115915 and 65855, respectively, are the main counties of the province that cover the water basin.

An unofficial reports surfaced indicating the presence of poisonous compounds of arsenic in groundwater of rural areas in Ghorveh and Bijar counties. The reports noted serious problems for the residents of the Ghezel ozan water basin. As a result of this study the existence of arsenic in groundwater resources of Ghezel ozan water basin and specially the villages of Ghorveh and Bijar counties of Kurdistan province of Iran was analyzed. Possible solutions were also explored.

EXPERIMENTAL

In order to monitor current status of water resources and particular analysis of the existence of arsenic in underground water supplies of the study area, water sampling was done in summer 2004 from suspected areas of the region. Nine villages in Bijar county namely; Ghorkhleh, Bashoki, Ebrahimabad, Gondak, Aliabad, Babanazar, Gheshlaq, Ghoradarband and Gugtapeh and 13 villages in Ghorveh county namely; Uchbolaq, Naranjak, Jafar, Hasankhan, Baharlu, Baryakhan, Khanabad, Qolqoleh, Toqanbaba, Qezeljakand, Guilaklu, Delbaran and Quchan were considered for water sampling. For sample collection, 500 mL polyethylene bottles were rinsed three times with the local underground water before being filled. The water samples for analysis of arsenic were immediately acidified with 1 % Merck quality nitric acid. Arsenic concentration was measured using ICP-MS according to EPA-3005 method in the hydro chemical laboratory of Tehran University.

RESULTS AND DISCUSSION

Arsenic affects people regardless of sex. It is a known carcinogen and has mutagenic and teratogenic effects. Reproductive and developmental effects of inorganic arsenic on humans and on animal species have been reported[11,12]. There is extensive documentation of reproductive and fetal developmental effects in a variety of animal species[13,14]. In contrast, there are few reports about effects of arsenic in drinking water on human pregnancy outcomes[15,16]. Higher spontaneous abortions (69.57/1000 live births) and stillbirths (7.68/1000 live births) were observed in high arsenic areas (where drinking water arsenic > 0.1 mg/L), compared to the control area (where drinking water arsenic < 0.1 mg/L); among controls, the rates for spontaneous abortions and stillbirths were 51.14/1000 live births and 2.84/1000 live births, respectively[15].

Chronic exposure of humans to high concentrations of arsenic in drinking water is associated with skin lesions[17,18], peripheral vascular disease, hypertension, blackfoot disease[18] and high risk of cancers[18,19].

Causing chronic adverse effects, arsenic intensively endangers human health especially when it is consumed long-term. In addition to increasing the risk of contracting lung, bladder, kidney and liver cancers, arsenic damages respiratory and nervous systems. Additionally, skin diseases like hyperkeratosis and pigment changes are also reported with arsenic poisoning.

The concentration of arsenic in the water samples collected from 22 villages located in Ghezel ozan water basin is shown schematically in Figs. 1 and 2. As it is seen, the arsenic concentration in all water samples is higher than that which is allowed by US EPA as the maximum contaminant level (50 ppb). The highest and lowest arsenic concentration are reported in Aliabad and Gugtapeh with 1500 and 52 µg/L respectively.

Continual droughts in the area have caused local water table to drop dramatically. Consequently, increased rate of oxidation in arsenic containing minerals of semi-saturated shallow layers has caused arsenic ions (As^{3+} and As^{5+}) enter the liquid phase. High concentrations of arsenic reaching more than twenty times above the acceptable upper limit of this contaminant in water were discovered as arsenic ions transferred from solid to liquid phase.

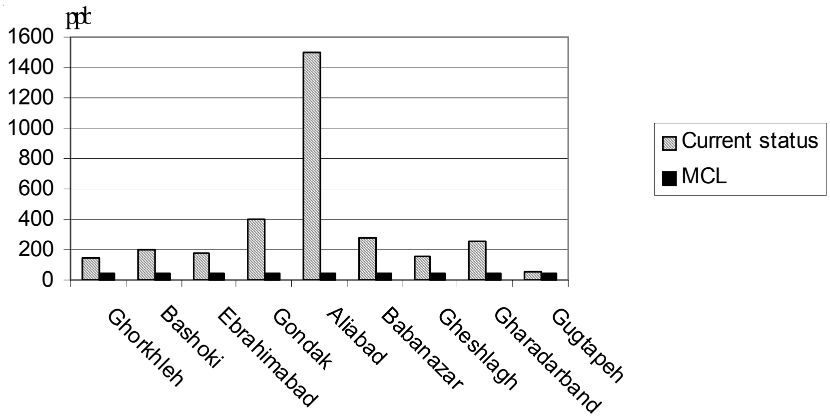

Fig. 1. Arsenic concentration in water samples collected from suspected villages of Bijar

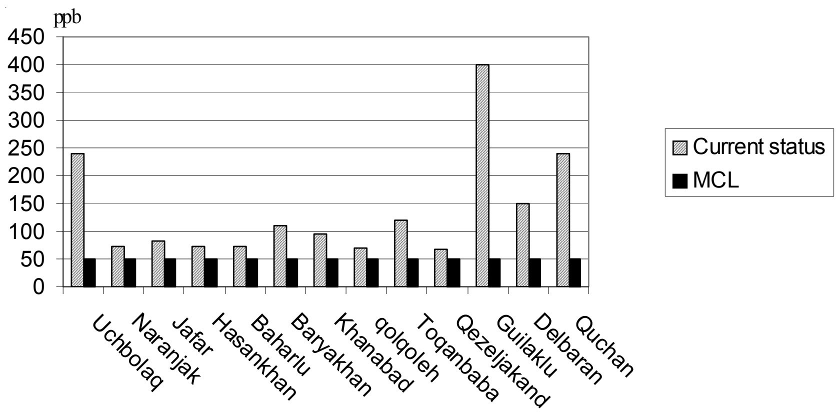

Fig. 2. Arsenic concentration in water samples collected from suspected villages of Ghorveh

Use of this water for drinking purposes may impose adverse effects on human health in present and future generations. Accordingly, some substitutions for supplying local drinking water must be considered. Because of the relatively high amount of annual precipitation in the region in the cold season, a sophisticated method in gathering, maintenance and use of this source may be considered for at least a limited period of the year. Furthermore, limited use of surface water rather than groundwater may lessen arsenic contamination risk; however, routine monitoring of surface streams must be performed by local authorities.

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