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Evaluation of Underground Water Contamination with Toxic Elements (Arsenic, Manganese, Fluoride and Magnesium) in Khost City

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Abstract

Water is considered one of the most important and basic materials of life, but for drinking, there must be such water that does not have bad effect on health. For this purpose, a lot of research has been done at the international level, in these researches the chemical composition of water has been determined that is suitable for health. Since mostly the people of Khost use the underground water for drinking purpose, so we considered it necessary to check the toxic elements (arsenic, manganese, fluoride and magnesium) in the underground water composition at Khost city, that more or less quantity of these elements has a very bad effect on health. The purpose of this research is to determine the toxic (arsenic, fluoride and magnesium) composition of underground water in Khost city and compare it with international standards and to know that can we use the underground water for drinking propose. This research, which was carried out at three places of underground water in the center of Khost province, found that the underground water at Khost city does not contain arsenic, the amount of manganese is below the permissible level, the amount of fluoride is within the permissible limit and the amount of magnesium is 0.28 mg/l which is less than the permissible level.

Keywords: Underground Water, Toxic Elements, Water Quality for Drinking, Arsenic, Manganese, Fluoride, Magnesium, Water Contamination.

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1. Introduction

Water is life. This vital fluid is the basis of life, health development and well-being. In developing countries during the last few decades, with the increase of population and industrial activities, on the one hand, the chances of contamination of water resources has increased, on the other hand, the demand for good quality water is increasing day by day. Among them, underground water resources are considered as a reliable source of natural filtration, because underground water plays an important role in the circle of human life. [6]

Water is an irreplaceable substance as a component and vital substance of the living environment, which plays an important role in ensuring health and avoiding of producing diseases. The importance of water in the lives of humans and other living beings has such a clear role that it does not need any reasons. Water is responsible for the transportation of substances to the body that form vital parts of the body. 65-75 percent of human body weight consists of water. Rapid growth of population, community development, agricultural and urban water needs, industrial and electrical needs have led to the scarcity of healthy drinking water. [20]

Groundwater is assessable both in terms of quality and quantity. All the attention in the developed and third world is to find suitable underground water reservoirs for irrigation, agriculture and industry. Meanwhile, very little attention is paid to underground water reservoirs. [4,19] The results of Fao studies have shown that water is unsustainable in 93 countries of the world, which means that the use of underground water is much higher than its renewal. [15] In order to protect public health, water that is available to consumers must comply with national and international standards. Studies have shown that dirty water causes various diseases, such as nitrite-contaminated water, low hemoglobin, and high nitrite water causes cancer in children. Nitrite pollution is considered to be a very serious problem at the international level. [26,27]

Fluoride is very important for humans, the appropriate amount of fluoride is used to prevent the attack of microbes on the teeth, especially in children. But long-term excess use of fluoride causes chronic fluorosis of the teeth and bones, neurological problems and Alzheimer's. [13,18] This problem exists in many parts of the world. While 250 million people in 25 countries are at risk from high fluoride concentrations in underground water. [1, 14]

A lot of research has been done around the world, as a result, the amount of water compounds has been determined in such a way that there is no harm to humans, animals and plants. These fixed amounts of compounds in water are accepted by health institutions and the available water around the world is compared to these and then decided about the purity and impurity of the water. [17] In this research, four type toxic elements i. e. arsenic, manganese, fluoride and magnesium toxic substances are studied, and we will discuss about them as below:

1. Arsenic: Arsenic is an element with the symbol As. This element does not found pure in nature, but it founds together with other elements such as gold, copper and zinc. This heavy element is very poisonous, it exists in soil and water. Arsenic-containing insecticides, when it used for killing insects, so increase the arsenic in the environment,

in result, this toxic elements enter the food cycle of humans and endanger human health, for example, the liver disease that occurred in fishermen in Japan was caused by fish contaminated with arsenic. [24]

Researches have shown that there is a problem of arsenic in major underground water bodies in the world, the concentration of arsenic in this water is more than 50µg/l. According to the guidelines of the World Health Organization, the amount of arsenic in drinking water should be no more than 0.01mg/l. In the beginning, the amount of arsenic was accepted 0.2 mg per liter (200 µg/l). In 1363, there was a revision in the section of drinking water, which reduced the amount of arsenic to 0.05 mg per liter (50µg/l). Later, in 1993 and 2011, the World Health Organization determined that the amount of arsenic in drinking water to be less than 0.01 mg per liter (10µg/l) because mineral arsenic was proven to cause cancer. Also, the World Health Organization has set the maximum amount of arsenic at 10 µg/l. [30]

When groundwater passes through rocks that have arsenic, so arsenic mixes with the water. Other sources of arsenic include the presence of arsenic in the earth's crust, the dissolution of minerals and industrial wastes in water, and the burning of fossil materials. [24] Large amount of arsenic is highly poisonous and can cause serious health problems, including death in some cases. The effect of arsenic is not immediately apparent in the case of small amounts, but continuous entrance of arsenic into the body has various effects on health and increases the risk of contracting chronic diseases. These diseases include: various types of cancer, narrowing of blood vessels, high blood pressure, heart disease and type 2 diabetes. Arsenic is a toxin that affects nerve cells and affects a person's actions. [22]

2. Manganese: Manganese is abundant in the earth's crust. It occurs in various forms such as Mn-II in the environments where air does not exist. Another form of manganese is Mn-IV which exists in the presence of oxygen. Mn-IV is in the form of an insoluble black sedimentary matter, while Mn-II is completely soluble in the form of Mn^{+2}. Surface water contains less than 0.1mg/l of manganese, but underground airless or vacuum water contains more manganese up to 1mg/l. Soluble manganese often coexists together iron, which is also soluble under anaerobic conditions.

Manganese is very important for humans, but studies have shown that if the amount of this element in drinking water increases, it can cause adverse neurological effects. Because of the potential health risks, the WHO has set a manganese content of 0.4 mg/l. It is not recommended for consumers to use the water containing more than this amount of manganese because the taste of the water deteriorates due to the presence of this metal. In addition, cases have been recorded in which the people are using water that have more amount of Manganese than the WHO amount such as Bangladesh. Manganese levels of 0.05-0.1 mg/l are acceptable to users, but sometimes lead to the deposition of black sediments on pipes. [25]

3. Fluoride: A concern of the medical community, especially dentists, is the presence of fluoride in drinking water. Fluoride is an element that exist in large quantities on the surface of the earth. Fluoride form three percent of the Earth's crust. Fluoride is found in small quantities in surface water reservoirs and in higher quantities in underground water reservoirs. The amount of fluoride in raw water is 0.1 to 1.5 mg/l. But in the composition

of underground water, this amount can exist up to 15 mg/l. Fluoride plays an important role in dental health. Fluoride prevents tooth enamel from dissolving and tooth decay in acidic conditions. Fluoride is an element that is useful in low quantity but harmful in high quantity. The main source of fluoride is drinking water, but small amounts are found in tea, salmon and sardine types of fish. One milligram of fluoride per day is required for adults and children. Fluoride should not exceed 3 mg because it is a toxic element. Increasing the amount of fluoride in the body causes dental and bone fluorosis and intestine diseases. That is, if the amount of fluoride exceeds 1.5 ppm and reaches 2-2.5 ppm, fluoresce starts in the teeth, and in this case, the beauty of the teeth is lost and the general appearance is affected. And besides, the transparency of the teeth also disappears. If the fluoride concentration reaches 4-8 ppm, it causes skeletal fluorosis, and drinking such water reduces bone growth in children. [11]

4. Magnesium: The important mineral cations in drinking water include: calcium, magnesium, sodium and potassium. Although iron ions are present in drinking water in low quantity, they have a greater impact on the quality of water because it causes corrosion of iron pipes and, as a result, spoils the smell and taste of water. Magnesium is the fourth most important cation that is essential for human life and is present in all cells and living tissues. Magnesium is abundantly found in vegetables. It exists in the porphyrin group of vegetable chlorophyll. It is also found in the tissues of many animals. Other important sources of magnesium include whole grains, beans, green vegetables, potatoes, almonds and dairy products such as cheese. Magnesium plays a significant role in activating the activity of many enzymes. Presence in the combination of bones and teeth, which contains 70% of magnesium in the enamel of the teeth and bones. Magnesium induces temporary and permanent hardness in water. An excess of magnesium in the water can be a laxative. Magnesium deficiency causes nervous disorders, chronic fatigue, back pain, muscle weakness, loss of appetite, insomnia, and irregular heartbeat. The maximum level of magnesium in drinking water is 100mg/l and the desired quantity is 30mg/l. [5]

2. Literature Review

A lot of research has been done in this area, some of which are mentioned here.

According to the report of the World Health Organization, one out of three people in developing countries do not have access to clean water. Also, 80 percent of diseases are caused by water.

A study was conducted in Taiwan that found that water contaminated with arsenic caused the development of arsenicosis. [28]

Geen and colleagues in Bangladesh in 2003 investigated 6,000 wells and the depth of drilling necessary to reach these low-As arsenic aquifers ranges from 30 to 120 m depth within the study area. [8]

A study conducted by Boyan and colleagues in 2010 near the coal mine in northwest Bangladesh revealed that the groundwater was 50% contaminated with heavy metals. [2]

In 2010, drinking water was analyzed by Yashbir in Sanganer, India. It was found that the water quality is not good and the amount of fluoride and nitrate in this water has increased due to artificial and natural sources. [12]
Hafiza Hamidi, a professor at the University, conducted an investigation on the water of Kabul, after which it was found that 56% of samples had less quantity of fluoride than the permissible level, 42% of samples had the quantity of fluoride within permissible level, and 2% of samples had more quantity of fluoride than the permissible level. 86% of samples had very hard water due to magnesium, 4% of samples had hard water and there was no sample that did not have hard water. Arsenic quantity in water for all areas were below the permissible limit of the international standards. [9]
Ali Akbar Mohammadi and colleagues conducted a research on the physical and chemical analysis of underground water in the Babol region of Iran, in result, it was found that the amount of nitrite, sulfate, chloride, sodium, electrical conductivity and pH are in standard condition. But the water turbidity, total hardness and iron were more than the permissible limit. And it was found that the amount of fluoride in 87.2 percent of the samples was less than the permissible level and 12.8 percent of the samples were within the permissible level. [16]

3. Research Methodology

For research, samples were taken from three points of Khost city in accordance with the rules, and then these samples were taken to a standard laboratory and analyzed according to international standards, in result all compounds have been identified. Those three are:

1. Near the ring road (University Road) of Khost city, there is an underground water source on the left side of Haji Mirnawaz Khan Plaza. This borehole is 80 meters deep and 14 inches in diameter. The GPS coordinates of this borehole are$(33°20′35″N\ 69°55′27″E)$.
2. The second sample was taken from an underground water source next to the Khost city project bridge near the main road of Khost Kabul. The depth of this borehole is 90 meters and its diameter is 14 inches. The GPS coordinates are $(33°20′8″N\ 69°54′28″E)$.
3. The third sample was taken near Mujahid Square in Khost city. The depth of this borehole is 85 meters and its diameter is 14 inches. The GPS coordinates are$(33°20′10″N\ 69°55′7″E\ )$.

Due to the non-availability of an equipped laboratory in Khost city, the water samples was transferred to Kabul and tests were performed there at the laboratory of Shawal Construction and Geotechnical Company. The address of this laboratory is Daburi, 3rd zone, 3rd Street, next to Behzad Private School, Kabul-Afghanistan.
After obtaining the results of the tests, these results are compared with international standards and the final results are mentioned.

4. Results and Discussion

Firstly, as a result of many studies, international standards for water were found and then compared with laboratory results.

Table 1 Quantities of Toxic Elements in Various International Standard in mg/l [29],[21],[23],[7][10][3]

No	Parameters	Chemical Symbol	WHO (2011)	SASO (1994)	US EPA (2018)	FDA (2008)	IBWA (2008)	BIS (2012)
1	Arsenic	As	0.01	0.05	0.01	0.05	0.01	0.05
2	Manganese	Mn	0.5	0.05	0.05	0.05	0.05	0.3
3	Fluoride	F	1.5	0.6-1.0	4	0.8-2.4	0.8-2.4	1.5
4	Magnesium	Mg	150	30-150	30-60	-	-	100

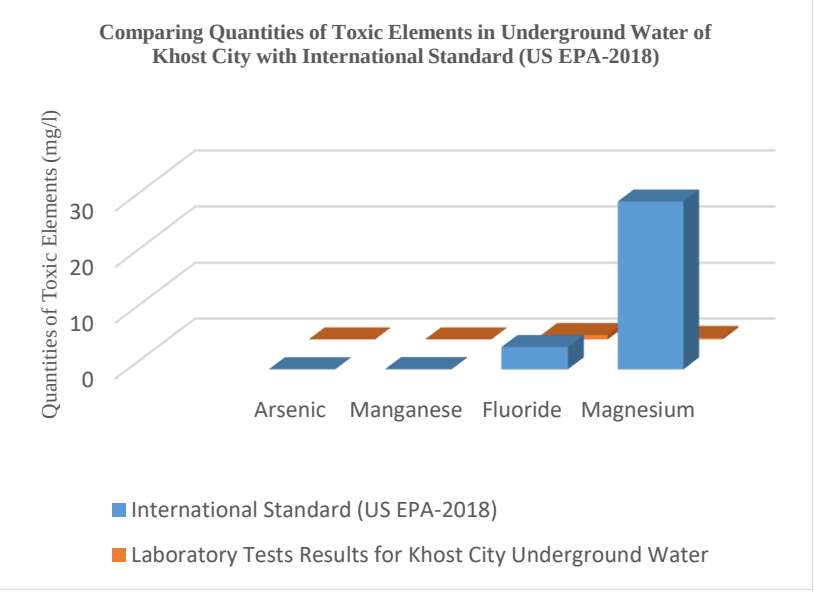


Fig. 1 Comparing Quantities of Toxic Elements in Underground Water of Khost City with International Standard (US EPA-2018)

Table 2 Arsenic, lead, fluoride and magnesium quantities (mg/l) for three centers after laboratory tests

No	Parameters	Center 1	Center 2	Center 3
1	Arsenic	0	0	0
2	Manganese	0.001	0.001	0.001
3	Fluoride	0.79	0.79	0.79
4	Magnesium	0.28	0.28	0.28

Since Khost city is not very wide, the results of all the centers are the same.

From the Fig. 1 above, it is observed that the amount of arsenic in the water is zero, so it can be said that the water of Khost city is not contaminated with arsenic. The quantity of manganese in the water composition is 0.001 mg/l, according to the all standards, this quantity is less than the standard amount. So it does not cause the water to taste bad. The quantity of fluoride in the composition of this water is within the permissible limits according to all standards and does not cause any problems. The amount of magnesium in the composition water is very low and it can cause some diseases.

5. Conclusion

In this research, the toxic elements (arsenic, manganese, fluoride and magnesium) in the underground water composition at Khost city have been studied, because more or less quantity of these elements has a very bad effect on health. The research was carried out at three points of underground water in the center of Khost province. The results of the research are concluded as following:

- From this study, it was found that the underground water of Khost city does not contain arsenic, and there is no problem for consumers.
- The quantity of manganese is not too high to cause the taste of water to deteriorate.
- The quantity of fluoride in this water is within the permissible limit and this water does not cause any problem due to fluoride.
- From the research, it was found that the amount of magnesium in this water is very low, which can cause some diseases, and a solution should be found as much as possible.
- In general the quality of underground water is good for drinking propose.

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