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Quantifying Water Quality in Northeastern Areas of Golestan Province Reservoirs in Terms of Heavy Metals (Chromium and Lead) and Fecal Coliforms

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ABSTRACT

Collecting and storing rainwater in reservoirs[1] have been common in Iran for various uses such as drinking. Gonbad Kavous located in the North-East of Golestan Province has 4142 water reservoirs to collect rainwater for drinking all of which are located in rural areas and are used by rural residents. In this city the reservoirs are cube-shaped and usually their capacity is 25 to 35 cubic meters. In general, right now the water reservoirs are made of concrete that make the reservoir impenetrable and increases the durability and strength of structure. In order to conduct this study under Cochran formula (to determine the sample size) the level of confidence α=0.05, the error rate was d=0.2, under pure ignorance (P=0.5) and population size (N= 4142), the sample size was estimated as 24 water reservoirs. Since the sampling period was 4 months and each month one sample was taken from the reservoirs, the total size of the obtained samples to be studied was 96 samples. For statistical analysis with a significance level of 95% SPSS 18 software was used. Separated tests and poor plate were performed on Microbial parameters including total coliforms, Escherichia coli and *Streptococcus faecalis*.

The results of this study showed that based on chemical parameters the concentration of lead in 12% and chromium concentration in4% of collected samples exceeded the allowed level and in terms of microbiological parameters total coliform in 75%, Escherichia coli in 25% of the parameters and *Streptococcus faecalis* in 11% were above the allowed range. Pearson correlation test showed that there was not significant relationship between levels of chromium and lead in water samples and the type of roof houses vegetation (α = 0.724). In addition, Pearson correlation test showed that there was a significant relationship between microbial pollution in reservoirs and rainfall (α = 0.015), so that in most biological samples carried out microbiological contamination has been observed after the rainfall.

Conclusion: The presence of faeces of birds and other contaminations in the roofs before the rainfall and the entrance of rainwater from the beginning of the rainfall as well as the absence of the clarification tanks can be among the reasons of water pollution in reservoirs. In addition, the sameness of the level of the roof of reservoirs with the hose yards has increased the penetration of surface waste and animal faeces from the water valve.

KEYWORDS: drinking water, lead, chromium, water reservoir

INTRODUCTION

Human health more than anything depends on clean water and sanitation, and basically human being life depends on clean water. Looking at the history suggests that the predecessors have achieved an appropriate technology to gain water resources and their distribution based on their cultural and climatic conditions. [1]

Many health problems in developing countries are due to the lack of healthy drinking water. The improvement of water distribution has significantly reduced the risk of numerous diseases. For example in India (in the state of Uttar Pradesh) after the improvement of water distribution, the rates of death from cholera, diarrheal diseases, typhoid and dysentery were reduced 74.1, 42.7, 63.6 and 23.1% respectively. [2]

[1] The equivalent term in Farsi is āb Ánbār

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Collecting and storing rainwater for various uses has been common in Iran and many other places. Collecting rainwater for drinking is still common in some regions of Iran. [3]

In ancient European civilizations the amount of water needed for drinking, cooking and washing was rare and some spaces were mixed with the building of houses to provide spaces for water by collecting rain water, such as roofs and paved yards. To stored water for domestic use, warehouses and water reservoirs were built and the use of drainage networks that linked the precipitation collector levels was common [4].

The evolution of this method refers to pre-history and a case of complex and detailed system to collect rainwater has been found in the ruins of Knossos Palace in Crete- Greece. Roman typical home design shows that the water supply for domestic use was based on rainwater collection in the Bronze Age. With the advancement and development of large cities, central water supply networks were founded to meet the domestic needs and rainwater collection lost its importance because the fulfillment of ware need exceeded this simple method. However, there are small areas the residents of which still use rainwater collection as a supplemental source to provide water because groundwater due to having too much salt are not good for such uses. Rainwater is collected by downpipes and stored in concrete or metal tanks to be used for washing and cooking. [3]

Iran is a country with little rain. Average annual rainfall is about 280mm. Rain distribution is not uniform around the country because the west and north of Iran are among the wet areas in which average annual amount of precipitation is about 580mm while the east side of Iran is a dry area with annual precipitation of 150mm. People in Arid and semi-arid areas in order to supply water for household and agricultural needs have to collect rainfalls in wet seasons to use it in times of need. [5]

In residential areas, water reservoir of most houses is equipped with downpipes that led the collected rainwater into water reservoir (Figure 1). In these regions people as soon as observing rain clouds cleaned the roofs and made the downpipes ready to transfer water. Thus at the onset of rains the collected waters were transferred to the reservoirs with least pollution [6]. In most cases water should be pulled up against the reservoir. For this purpose rope and bucket is used which make water polluted and other methods should be used. In this regard, the use of hand pumps can be useful. The pumps can be installed in a fixed form, and if used correctly they will work for a long time [7].

Figure 1: An example of a reservoir in the city of Gonbad Kavous

Drinking water should not contain any pathogenic micro-organisms. Also the drinking water must be free of fecal pollution indicator bacteria. To ensure that drinking water provides these recommendations, water samples

should be tested regularly to detect fecal contamination. For this purpose bacteria suggested as indicators are Coliform group of organisms. The recognition of FAECAL COLIFORM ORGANISMS especially ESCHERICHIA coli is the reason for feacal contamination of water. Humans generally contact with harmful chemicals by three ways: 1-breathing, 2- eating and drinking 3- body contact with this material. The most important way to contact with these toxins is through the mouth, human being is infected through eating and drinking them. Some experts believe that the emergence of different types of cancer and mental and neurological diseases, hormonal disorders, endocrine and genetic are directly or indirectly dependent on the presence of these toxins found in our environment. Since drinking water is one of the most important means of transmission of these materials mire attention should be directed toward pollution. [8]

Salts of the metals (lead and chromium) are rarely found in water but may be created in water by the water containing the materials that react with these elements and the salts of these metals are often toxic and must be controlled in the water. [9]

The excessive amount of some toxins as lead (Pb) and chromium (Cr) in water can be a reason for their lack of application for general uses [10].

Golestan Province is one of most beautiful green areas in northern Iran with an area of 22 thousand square kilometers which is located in southeast of Caspian Sea limited in the North, South, East and West with Turkmenistan, Semnan, Khorasan and Mazandaran provinces respectively (Fig. 2). Golestan province has two completely different climates as the south part of the province is a mountainous region covered with dense forests and in the north of the province there is a low desert in the north. The average annual rainfall in the south is 700mm and in the north 200mm with the average rainfall of 450mm which is higher than the average rainfall in the country (250 ml). The amount of average annual evaporation in the north is 2000mm and 800mm in the south [11, 12].

In a study conducted by Zafarzadeh et al in 1999 of the on chemical and bacteriological water quality of the reservoirs in Minoodasht, the concentrations of lead and chromium and ESCHERICHIA coli were higher than the allowed range in 56, 6 and 32% of the samples respectively. [13]

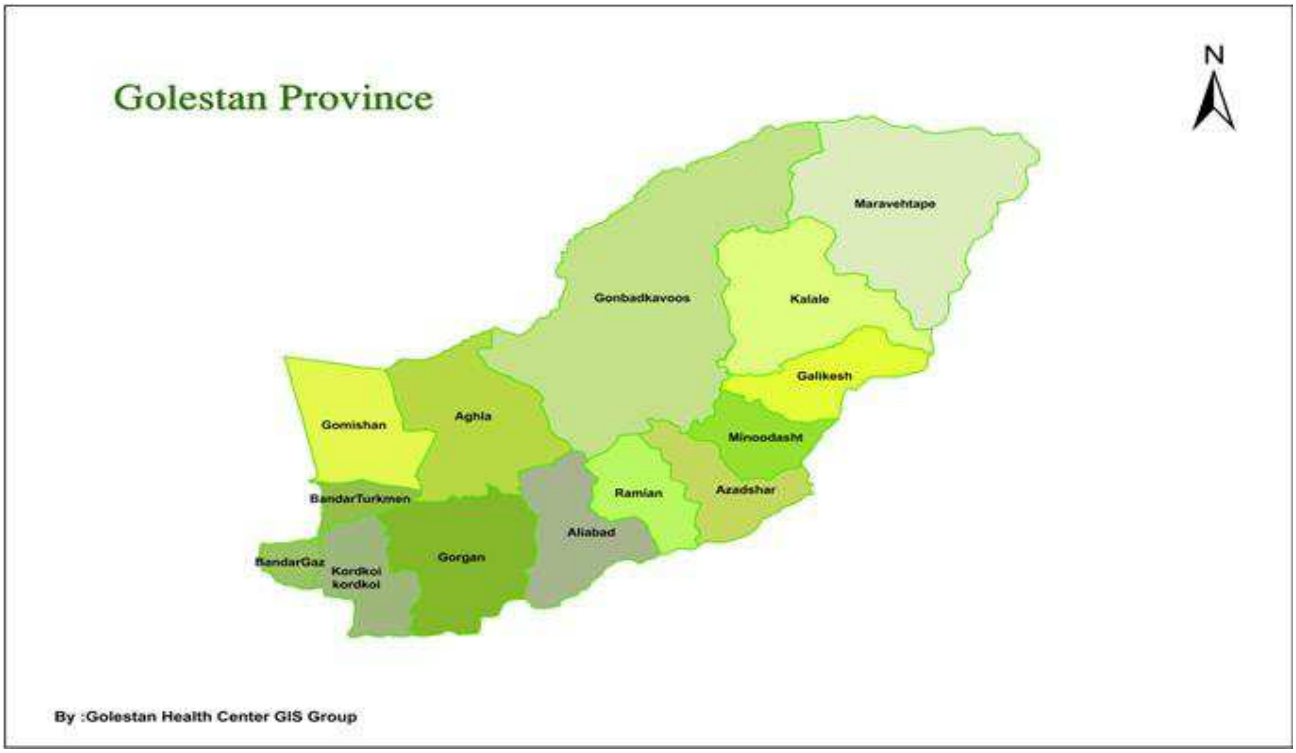

Figure 2: Geographic Location of Golestan Province

METHOD

In order to conduct this cross-sectional study first, the reservoirs of the area under study were identified and counted. Then by providing the map the location, number, capacity and water sampling method were studied. Then, using the Cochran formula (N=4142), 24 reservoirs were selected to be studied. After this stage, at least four samples were collected based on biological and chemical sampling through the standard protocols.

Chemical water samples were kept in plastic containers free from any chemical contamination to determine the concentration of chromium and lead and transported to the laboratory adjacent to ice bags and their levels of lead and chromium were observed by atomic observation devise. In the case of the interval between the time of sampling and testing of heavy metals, samples should reach the pH of less than 2 with nitric acid 72% and then kept in refrigerator to prevent changes caused by evaporation [14].

Water biological samples in order to determine fecal coliform were collected in sterile glasses with sand lids and transported to the laboratory adjacent to cold box. All tests were conducted by multi-tube microbial fermentation method. The results of experiments were analyzed using SPSS 18 software.

Results

The results of this study showed that among all 96 water samples tested chemically in 2012 collected from 24 reservoirs and analyzed by spectrophotometer atomic observation, lead concentrations in 12% of collected samples was over 0.01mg per liter(Maximum allowable concentration set by the World Health Organization). And in addition the concentration of chromium in 4% of collected samples was over 0.05mg per liter (Maximum allowable concentration set by the World Health Organization) [15]. In addition, according to the World Health Organization suggestion [15] based on the fact that the number of fecal coliform per 100 ml of drinking water should be zero; among 96 samples of water samples tested biologically, total coliform in 75%, Escherichia coli in 25% of the parameters and *Streptococcus faecalis* in 11% were above the allowed range. Pearson correlation test showed that there is no significant relationship between measured levels of chromium and lead in water samples and the type of roof cover (tin or roof insulation) ($\alpha = 0.724$)

DISCUSSION AND CONCLUSION

Lead and chromium

The results of this study showed that the concentration of lead in water samples for chemical testing, varied between 0.001 to 0.937 mg/lit and the concentration of chromium in water samples for chemical testing varied between 0.001 to 0.041and these variations fluctuated at different times and the minimum and maximum values cannot be associated with a specific sampling time, also based on Pearson correlation test the type of roof cover (tin or roof insulation) did not affect the amount of lead and chromium in water reservoirs. Perhaps one of the factors affecting the level of lead and chromium in water reservoirs is the use of surface water such as Gorganroud to provide and supply water required by households that might include a certain concentration of lead while passing through mountains and plains. Another possible factor to increase the amount of lead in the water stored in the reservoirs in the region is the passage of veicles that use fuel containing lead that makes results in the entry of lead into the air and then into the reservoirs through the rain.

MICROBIAL RESULTS

According to the World Health Organization suggestions [1 5] Maximum fecal coliform per 100 ml of drinking water should be zero but the number of fecal streptococci (*faecalis*) is not mentioned. The results of biological samples taken showed that the water in the reservoirs had ESCHERICHIA coli, fecal coliform and *Streptococcus faecalis* pollutions.

Pearson correlation test showed that there was a significant relationship between microbial pollution in reservoirs and rainfall ($\alpha = 0.015$), so that in most biological samples carried out microbiological contamination has been observed after the rainfall.

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