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Status of heavy metals contamination in drinking water of district D. G. Khan, Punjab, Pakistan

Abstract

Anthropogenic activities are the major cause of environmental pollution. Industrialization, urbanization and agriculture activities are also causing huge troubles linked to human health in Pakistan. Heavy metals contamination has increased in drinking water because of urbanization and agricultural activities. Being one of the urbanized Cities, Dera Ghazi Khan has also been subjected to the hastily increasing harms of contamination. The respective study was planned to evaluate the heavy metals concentrations and identification of high risk areas for the inhabitants living in the city. Total ninety-six samples of drinking water were collected. TDS and EC were in the range of 1.48 to 8.412 mg/L and1.41 to 9.4µS/cm respectively. TSS was from 40 to 599 mg/L which were exceeding WHO guidelines in eight samples. Heavy metals such as Ni, Cr, Zn, Pb and Cd were measured through atomic absorption spectrophotometer. Zn average value was well within WHO standard while Pb was exceeded in thirty-nine samples. Cd was exceeded in fifteen samples; Cr and Ni were exceeded in eighteen samples. Sources of heavy metals identified as agricultural activities, domestic and commercial effluent. Ground water samples were found potable at some locations but at the same time pose serious threat to human health due to heavy metals above permissible limits.

Keywords: drinking water, heavy metals, environmental, pollution, dera ghazi khan

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Introduction

Water is a universal solvent, having ability to dissolve lethal organic and inorganic compounds which are not only deteriorating the water's worth but also effects consumer's fitness.[1] The total percentage of fresh water on the earth is 3-4% while 0.01% is used for human needs.[2] In developing countries, more than 80% population use ground water for drinking purposes.[3] The heavy use of fresh water in industry, agriculture and municipal facilities is causing contamination in fresh water while the demand of uncontaminated water is rapidly increasing in most polluted regions.[5] Presence of some trace elements is reported to be necessary for human health in drinking water but the elevated concentration or the accumulation of these trace metals may cause harmful effects.[5]

Inorganic pollutants occur naturally or industrial influences or watershed from farming include many heavy metals like Zn, Cu, Cr, Mn and Ni.[6] The elements which have more than 6 g/cm^3 atomic density are known as heavy metals and most persistent pollutants in water.[7] The certain absorption of heavy metals become toxic when they exceed from permissible limit[8] while heavy metals are disseminated in all mediums of nature such as water, air and soil. Some heavy metals are present at low concentration in every medium of nature and they can carry about massive destruction to the environment when their consumption exceeds from the safe limit.[9]

In Pakistan, drinking water quality and its progresses is an important problem and about 44% of total population has no access to harmless drinking water.[10] Drinking water must be secured from illness producing agents before human consumption.[11] Surface and ground water sources in Pakistan contaminated and international standards for chemical limits for drinking water cannot follow.[12] Two other factors Koh-e-Suleman in the west of city and Indus river in the east are also responsible for changing chemical behavior of ground water to make it unfit for human consumption.[13] The demand of pure drinking water has increased with this tremendous increase in population. The purpose of the study was to evaluate the drinking water quality available for the population of Dera Ghazi Khan City, built on a set of precise parameters. The main objectives of the study were following:

I. Determination of concentration of heavy metals such as Pb, Ni, Cr, Cd and Zn in drinking water of D. G. Khan city

II. Determination of variation in chemical composition of drinking water from block to block and block to source and identification of high risk areas for the inhabitants living in the city of D. G. Khan.

Materials and methods

Study area

D. G. Khan (Lat: 30º; Lon: 70º), is the district of Punjab province (Pakistan) was selected as study area to assess heavy metals contamination in drinking water. The average annual rainfall of Dera Ghazi Khan is 155 mm. Temperature of the D. G. Khan city during summer season usually about 46 ºC and during winter season becomes very low reaching 4 ºC.

Sample collection

The samples were collected from 32 different locations of D. G. Khan city from hand pumps with different depth ranging from 10 to 50 m which were used for drinking purpose (Figure 1). Total ninety-six samples were collected. Samples were collected in polyethylene bottles (PET) with 1 liter capacity. Before filling the sample bottles were rinsed by distilled water. For physico-chemical parameters, the samples were preserved in ice box at 4 ºC before the analyses.

Analytical methods

Temperature measurement was done on the sampling site through using the mercury filled Celsius thermometer. Multimeter Crison

(MM40+) was used to check the pH (APHA, 2005). By using multimeter Crison (MM40+), electrical conductivity was measured of all the obtained samples in the laboratory (APHA, 2005). Furthermore, using same multimeter Crison (MM40+) the concentration of total dissolved solids were also estimated. While total suspended solids were measured by using micro filters and drying the residues at 103-105 ºC as per following standard methods (APHA, 2005).

Figure 1 Map (From Google Map) of Dera Ghazi Khan showing sampling sites of the study area.

Heavy metals

Lead, chromium, cadmium, zinc and nickel concentration in water samples were determined through atomic absorption spectrophotometer (AAS) (GBC 932+ following APHA (2005). The detection wave lengths for Pb, Cr, Cd, Zn and Ni were 217 nm, 357.9 nm, 228.8 nm, 213.9 nm, 232 nm, respectively.

Statistical analysis

Descriptive statistics was applied for the data analyses while t-test was performed in order to compare the results of the study with WHO and GoP guidelines value. Furthermore MS Excel and Statistix (ver. 8.1) softwares were used to manipulate data.

Results

The Consumption of heavy metals through water and food chain is a major threat to human and its environment. Heavy metals contamination is prominent in increasing its destructive impacts. So, the quality of drinking water was tested by obtaining samples from thirty two different locations in the D. G. Khan City and six significant drinking water quality parameters (temperature, pH, EC, TDS, TSS and five heavy metals) in obtained ninety-six samples were investigated.

Temperature

Temperature measurements of the collected samples from all thirty-two sampling site ranged from 20.5 to 28.3 ℃. Lowest temperature was measured at sampling site of Block K within average temperature of 20.5 ℃ and highest temperature within average temperature of 28.3 ℃ was observed at location 'Pul Daat'.

pH

The pH concentration of the obtained samples from all the thirty-two locations was found in the range of 6.98 to 8.17. Among all the sampling sites, in sampling location block 42 lowest pH value was determined (6.98), while in sampling site of 'Chouratha' highest pH value was found (8.17).

Electrical conductivity (EC)

The EC measurements ranged from 1.41 to 9.4µS/cm. The lowest EC concentration was measured in 'Mastoi Abad' within average concentration of 1.41µS/cm and at location Block D, highest mean concentration was measured within 9.4µS/cm among all sampling site.

Total dissolved solids (TDS)

The mean concentration of TDS ranged from 1.480 to 8.412 mg/L from the entire sampling site. The lowest TDS value was also observed in 'Mastoi Abad' with mean concentration of 1.41 mg/L and highest average concentration was observed at Block D within 8.412 mg/L.

Total suspended solids (TSS)

The TSS concentration measured for all the ninety-six samples from all the locations of D. G. Khan ranged from 40 to 599 mg/L

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among all the samples. Highest concentration was found at 'Abbas Abad', 'Allah Abad' and 'Chouratha' with the mean concentration of 599 mg/L, 590 mg/L and 573 mg/L respectively.

Heavy metals

Concentrations of five heavy metals in all the ninety-six samples collected from different thirty-two location of Dera Ghazi Khan City were investigated.

Zinc

Zinc was not detected in the samples of two locations. The values of Zn in all the samples of D. G. Khan were less than 3 mg/L. Average concentration of Zn was observed ranging from 0.229 to 2.524 mg/L. Zinc concentration in all the samples was below the WHO guidelines limits (Figure 2).

Chromium

The chromium concentration was found at nine locations of different sampling site of the D. G. Khan city. The average concentration of Cr ranged from 0.035 to 0.049 mg/L among all the samples which was below the WHO guidelines level (Figure 3). Overall mean concentration of chromium of D. G. Khan in drinking water was 0.0043 mg/L. The lowest concentration was observed at 'Abbas Abad' with the average concentration of 0.035 mg/L but highest concentration was observed at Block 28 and 'Chouratha' with same mean concentration of 0.049 mg/L.

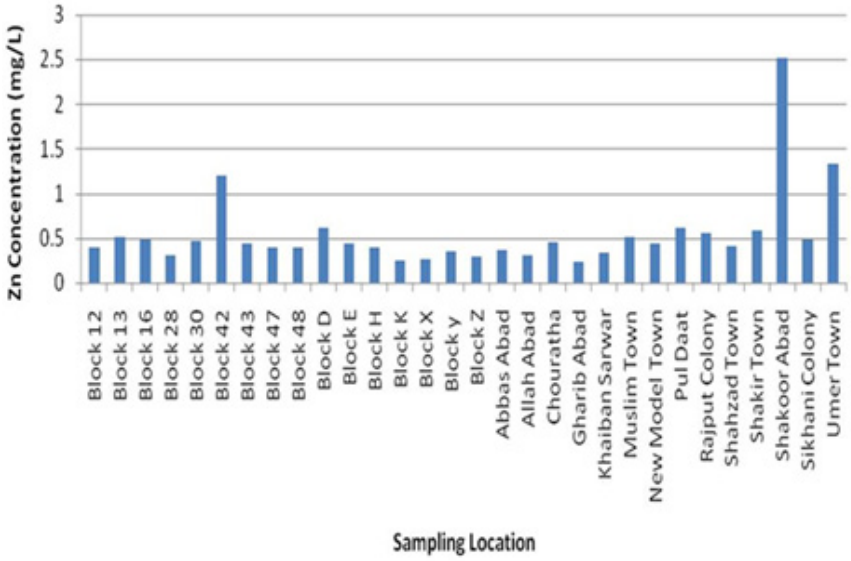

Figure 2 Mean values of Zinc observed in collected drinking water samples.

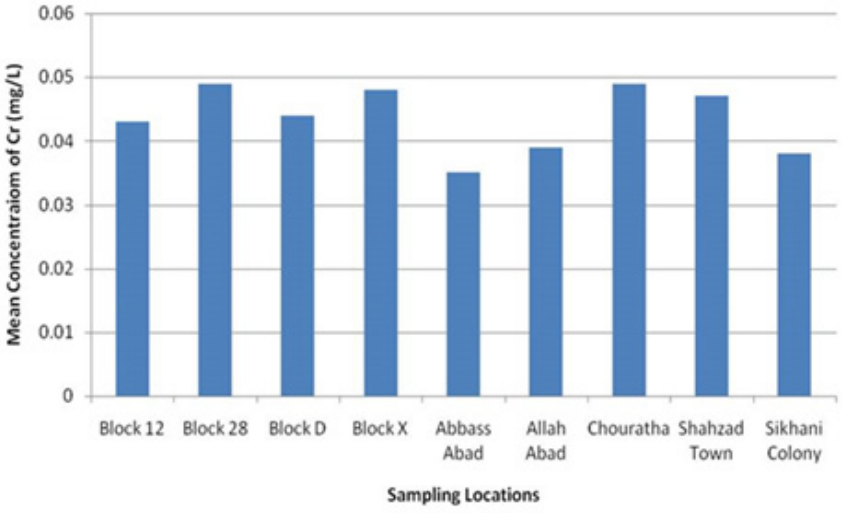

Figure 3 Mean values of Chromium observed in collected drinking water sample.

Nickel

Nickel Concentration was detected from seven different locations of the city in twenty-one samples of water. The mean concentration of Ni ranged from 0.027 to 0.051 mg/L among all the samples. Highest concentration was observed at 'Umer Town' with the mean concentration of 0.051 mg/L. Overall average concentration of Ni was found to be 0.042 mg/L in the samples (Figure 4).

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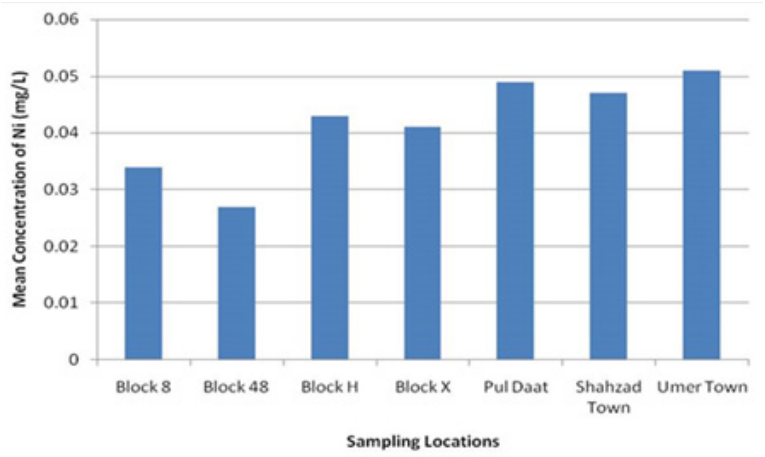

Figure 4 Mean values of Nickel observed in collected drinking water samples.

Cadmium

Cadmium concentration was observed highest at sampling site of 'Chouratha' with the average concentration of 0.005 mg/L. Overall mean concentration was observed 0.0038 mg/L among all the samples (Figure 5).

Lead

Lead concentration was observed highest at sampling location 'Chouratha' with the mean concentration of 0.049 mg/L while it was observed lowest at sampling location Block 16 with the mean concentration of 0.007 mg/L (Figure 6).

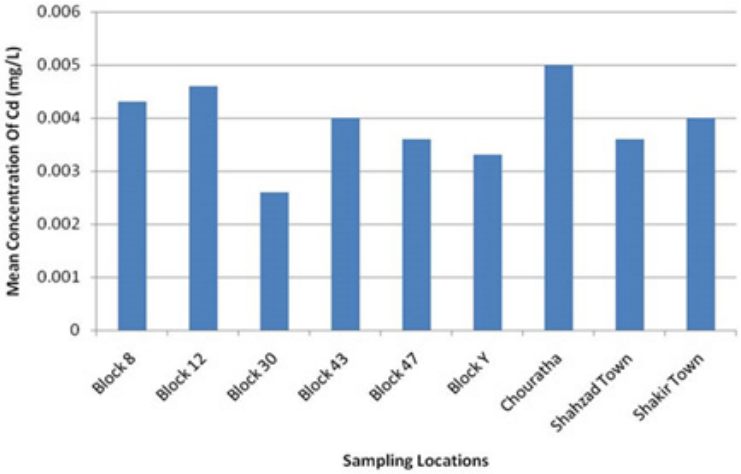

Figure 5 Mean values of Cadmium observed collected drinking water samples.

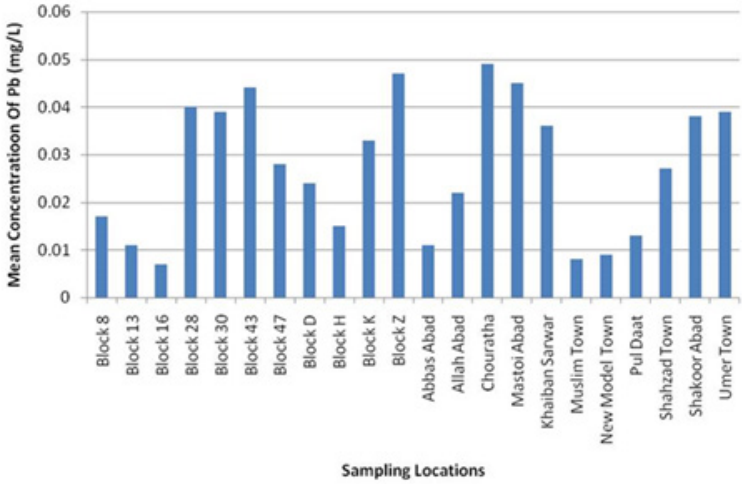

Figure 6 Mean values lead observed in collected drinking water samples.

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Discussion

Physico-chemical parameters like temperature, pH, EC, TDS and TSS results showed a considerable relation among all the samples. Odorless results obtained in drinking water of D. G. Khan city among all the samples which were within WHO guidelines and showing well aesthetic qualities. pH of water is considered as the most significant parameter for testing water quality which shows the acid base stability and is used as a tool for analyzing the water chemistry.[14] pH in most of the samples of study area showed significant relation with the low concentration of heavy metals. Electrical conductivity (EC) was measured in the range of 1.41 to 9.4µS/cm, which was high in all the samples of water. The areas which are near to the mountains of 'Fort Munro' in the west may be the possible reason for high values of EC due to their geographical location. Increase rate of ions in water is directly linked to electrical conductivity because of mineral weathering, nitrate and sulphate concentrations. Total dissolved solids concentrations were exceeding from WHO limits. It was observed that average values of TDS and EC give coincidence relationship between two values from all location in this study. The concentration of suspended particles and values of metals have a strong correlation.[15] According to the U.S. EPA (2000), total suspended solids are formed on the basis of mineral content in water. The concentration of TSS in drinking water of D. G. Khan was found in satisfactory condition in eighty-eight samples i.e. within WHO limits.

In the current assessment, the drinking water samples were observed to have the cadmium concentration in the range of 0.0026 to 0.005 mg/L. The high concentration of Cadmium was measured in eighteen samples in those areas which are located in the west near mountains of Koh-e-Suleman and vehicular activities are more than other areas. The lowest concentration was observed at 'Abbas Abad' with the average concentration of 0.035 mg/L but highest concentration was observed at Block 28 and Chouratha with same mean concentration of 0.049 mg/L. Dissolution of chromium from rock strata may be considered as source in drinking water of D. G, Khan because of Fort Munro Hills in the west. In the obtained samples from different locations, lead average concentration was observed in the range of 0.007 to 0.049 mg/L. Agricultural activities can be considered as the major source of Zn contamination in drinking water of city. The mean concentration of Ni ranged from 0.027 to 0.051 mg/L among all the samples except one sampling site (Block 48). Highest concentration was observed at 'Umer Town' with the mean concentration of 0.051 mg/L. Leaching from mining, industrial activities and weathering from different types of rocks can be considered as the sources of Ni contamination in drinking water.[16] So the waste material from cement factory and Ghazi tractor factory may be the source of Ni contamination in city. Heavy population, commercial and domestic effluent and agricultural activities are responsible of variation among heavy metals in drinking water. On current data basis, following recommendations are made:

I. Water treatment plants should be installed at different locations of city to ensure the access of clean drinking water. So that heavy metals contamination could be checked.

II. A centralized sewerage system should be developed in D. G. Khan city as well as its marginal regions to evade domestic waste percolation seeping in to the aquifer.

III. Regular monitoring of all water resources and water points should be ensured to help determine problem regions, source of pollution and design a frame work of corrective plans.[17–33]

Acknowledgments

None.

Conflicts of interest

The author declares there is no conflict of interest.

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