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# Quality of drinking water from filtration plants in Rawalpindi region of Pakistan

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## Abstract

Majority of our population does not have access to clean drinking water in Pakistan. Quality of tap water is highly unreliable and people use water from filtration plants installed by the Punjab government for drinking purpose. The purpose of this study was to analyze the quality of drinking water from twelve filtration plants in Rawalpindi region. Fifteen parameters were studied including EC, magnesium, calcium, turbidity, lead, zinc, manganese, chromium, sulfate, nitrate, chloride, hardness, pH, dissolved oxygen (DO) and Fecal coliform bacteria. Analytical work was carried out in in the Department of Soil Science, PMAS- Arid Agriculture University Rawalpindi. It was noted that nitrate concentration was high in five water samples. No water sample was found contaminated with fecal coliform bacteria. EC, pH, calcium, sodium, turbidity, sulfate and dissolved oxygen were found as per WHO guidelines. Manganese and zinc were either not detected or they were in small amounts which was within safe limit. Cr content ranged from 0.098 to 1.26 mg/L while Pb content in two water samples was 0.09 and 0.129 mg/L respectively. It was concluded from this study that 80% of drinking water samples were fit for drinking purpose and 20% drinking water samples were unfit for drinking because of high concentration of chromium and Pb. There is immediate need to resort to protective measures and treatment technologies to deal with high chromium content of drinking water.

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## Introduction

Drinking water quality and its improvement is one of the significant issues in the water sector in Pakistan. About 45% of the total population of Pakistan has no access to safe drinking water (Farooq *et al.,* 2008). According to WHO recommendation, drinking water must be treated to secure it from disease producing organisms and toxic chemicals before human utilization (WHO, 2006). Such treatment is at minimum level in Pakistan and no such international standards are followed to implement microbiological and chemical limits of drinking water. In Rawalpindi region, more than 40% of human diseases have been attributed to the utilization of low quality water (Farooq *et al.,* 2008).

The deteriorating water quality in developing countries is the cause of diarrhea (Clasen *et al.* 2007), hepatitis E, dental carries and oral hygiene (Khan *et al.,* 2001), anemia in children (Stephenson *et al.,* 2000), reducing intelligence in children and brain functioning and development (Dillingham and Guerrant, 2004). The principle sources of contamination in water are farming or industrial discharge (Afzal, 2006) including manganese, chromium, lead, copper, iron, zinc and nitrate (Paustenbach *et al*; 2003). In water, presence of trace metals is a definite drawback for water quality arising from agricultural, domestic and industrial waste. Presence of these trace metals may result in adverse health effects varying from shortness of breath to several types of malignancies (kavcar *et al.,* 2008). Nitrate arising from unnecessary utilization of nitrogen fertilizers, leaching of waste water or other organic wastes into surface, has been associated with amthaemoglobinaemia (Kazmi and Khan, 2005). Sulfate is natural component of water but the concentration of sulfate fluctuates significantly depending upon the source of water. If the concentration of sulfate is greater than 250 mg/L in drinking water it may causes diarrhea (Bartram and Balance, 1996). If the manganese presence in water is higher than 0.5 mg/L of water it affects color, odor, taste and ultimately human health (Dimirkou and Doula, 2008). Most of the people in Pakistan use ground water for drinking purposes. A study conducted by National Institute of Health (NIH) concluded that even water in capital city and adjoining areas was not completely safe for drinking. The purpose of this study was to investigate the quality of drinking water from selective filtration plants in Rawalpindi region.

## Materials and methods

*3.2 Collection of water samples*

Samples were collected from selective water filtration plants of Rawalpindi region. Samples were collected from different localities including Faizabad, Shamsabad, Iqbal Town, Rehamnabad, Murgi Mandi, Chandni Chowk, Rehmanabad, Committee Chowk, Raja Bazzar, Statelite Town, Saddar and Eid Gah filtration plants in Rawalpindi region. Water flow was allowed for two to three minutes to discharge the stagnant water prior to collection of filtration plant water samples. Plastic bottles were used for sample collection these bottles were already washed with distilled water. For physicochemical parameters, bottles were washed thrice with same water and then filled with samples. Biological samples were also taken from the selective filtration plants. These samples were placed in a cooler having ice slurry in order to minimize microbiological and chemical change during transportation to laboratory.

*Analytical methods*

Electrical conductivity of water was determined by EC meter (2510, APHA, 2005) Temperature, TDS and pH were recorded on the spot with portable TDS (3325, APHA, 2005) and pH meters (2550, APHA, 2005) respectively. Dissolved oxygen (DO) was determined by Azide Modification Method (2510, APHA, 2005), hardness by titrating with ethylenediamine tetra acetic acid (2340C, APHA, 2005). Turbidity in nephelometric turbidity units (NTU) using a turbidimeter by nephelometric method (2130, APHA, 2005). Bacteriological quality (coliform bacteria) was estimated by MPN technique. Sodium was directly determined by using flame photometer (EEL 712700) while chloride was determined by titration method (4500C, APHA, 2005). The concentration of metallic

elements (Cr, Pb, Mn, Zn) was determined directly by atomic absorption spectrophotometer (Shimaduzu AA-670) using air-acetylene flame in combination with single-element hollow cathode lamp.

*Statistical analysis*

Descriptive statistics was applied using statstix 8.1 for interpreting the results.

**Results and discussion**

*pH, EC, hardness and turbidity of water samples*

The pH is an important parameter of water quality that indicates the acid-base equilibrium in natural and fresh drinking water. The pH of the water samples from selected filtration plants in Rawalpindi region varied from 6.5 to 7.94 (Table 1).

**Table 1.** Various chemical parameters of water samples collected from filtration plants in Rawalpindi region.

| | Total number | Mean | SD | C.V. | Minimum | Maximum |
|---|---|---|---|---|---|---|
| pH | 12 | 7.2 | 0.39 | 5.4 | 6.5 | 7.9 |
| EC (us/cm) | 12 | 363 | 8.6 | 2.3 | 350 | 375 |
| Turbidity(NTU) | 12 | 1.6 | 0.6 | 35.7 | 1.04 | 2.6 |
| DO (mg $L^{-1}$) | 12 | 3.2 | 1.8 | 56.0 | 1.2 | 7.8 |
| Hardness | 12 | 102.6 | 39.2 | 38.2 | 60 | 190 |

The highest pH was noted at Chandni Chowk (7.94) and the lowest pH value (6.5) was observed in Iqbal town filtration plant. However, it was within the range suggested by WHO (6.5-8.5).

Electrical conductivity (EC) is another important water quality parameter which indicates the quantity of dissolved salts in water. Electrical conductivity of water samples ranged from 350-375 µS/cm (Table 1). The highest EC (375 µS/cm) was in water sample from Faizabad filtration plant while the lowest EC (350 µS/cm) was recorded in water sample obtained from Chandni Chowk filtration plants. For normal water quality EC should be below 400 µS/cm (WHO). So according to this criterion, the EC of water samples was in acceptable range.

Turbidity is associated with the risk of microorganism contamination in drinking water. Increase in turbidity level can provide medium for microbial growth and generate water borne diseases (Kent *et al.*, 2000). Turbidity of water samples from the study areas ranged between 1.04 to 2.6 NTU with mean value of 1.05 (Table 1). The highest value (2.6 NTU) was noted in statelite town water samples. The lowest turbidity (1.04 NTU) was observed in Shamsabad. This high turbidity could be due to higher fecal counts and contaminations (Qaiser *et al.*, 2014).

Hardness of water samples ranged from 60 to 190 mg/L (Table 1). Highest value (190 mg/L) of hardness was observed in Committee Chowk filtration plant while minimum value (60 mg/L) was recorded from filtration plant in Chandni chowk.

*Chlorides, nitrate, calcium, sulfate, dissolved oxygen and sodium content of water samples*

Nitrate concentration ranged from 0.35 to 55 mg/L in the drinking water of the given study area (Table 2). The highest concentration (55 mg/L) was recorded in Chandni Chowk followed by Murgi mandi (54 mg/L) and Raja Bazaar (53.3 mg/L). Nitrate concentration in all the water samples was below WHO guideline except five samples. Sixty percent water samples did not exceed the permissible limits. Some water samples taken from Chandni Chowk, Murgi Mandi, Iqbal Town, Statelite Town and Raja Bazar Iqbal town exceeded the permissible limits while $NO_3^-$ content in water samples from Shamsabad (0.35 mg/L) and Eid Gah (2 mg/L) was within safe limits. Presence of nitrates in water is specifically associated with the utilization of chemical fertilizers (Reid *et al.*, 2003).

Lesser utilization of fertilizers and pesticides in Rawalpindi could be a reason to bring down the nitrate fixation in fresh drinking water. Ezeonu *et al. (2008)* reported that nitrate in drinking water played

an important role in gastric carcinogenesis. They noted a strong relationship between nitrate concentration and recurrent diarrhea. They were of the view that 80% of the recurrent diarrhoea cases were explained by nitrate concentration alone.

The sulfate content of water samples ranged from 0 to 1.09 mg/L which was much less when compared with the WHO permissible limit (400 mg/L) for water. So, all the water samples were safe so for as the concentration of $SO_4^{-2}$ was concerned (Table 2).

**Table 2.** Sodium, calcium, chlorine, magnesium, sulphate and nitrate content of water samples collected from filtration plants in Rawalpindi region.

| | Total number | Mean | SD | C.V. | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Sodium | 12 | 79.8 | 23.7 | 29.7 | 45.7 | 130 |
| Calcium | 12 | 57 | 7.2 | 12.7 | 47 | 68 |
| Chlorine | 12 | 4.4 | 3.1 | 71.7 | 1.5 | 9.5 |
| Magnesium | 12 | 46 | 2.9 | 6.3 | 43 | 51.1 |
| Sulphate | 12 | 0.3 | 0.28 | 91.7 | 0.1 | 1.09 |
| Nitrate | 12 | 34.12 | 22.5 | 66 | 0.35 | 55 |

All units are in mg $kg^{-1}$.

Sulfates naturally occur in some areas where mineral deposits and rocks are high in sulfate content. Sometimes industrial waste also raises $SO_4^{-2}$ concentration level in drinking water in some areas (Karavoltsos *et al.,* 2008). However all the water samples analysed were very low in sulfate content.

Calcium and magnesium content of water samples ranged from 50.1 to 68 mg/L and 43 to 51.1 mg/L respectively (Table 2). WHO limit for Ca and Mg in water is 75 and 50 mg/L respectively. Calcium and Magnesium content of all water samples was within safe limit except one water sample where Mg was 51.1 mg/L which is not big deviation from recommended value. The highest calcium content (67.4 mg/L) was noted in Eid Gah filtration plant and the lowest (47 mg/L) was recorded in Raja Bazar area. On the other hand, the highest magnesium content (51.1 mg/L) was recorded in Committee Chowk and the lowest (43 mg/L) was found in Murgi Mandi filtration plant. So far as the fecal coli form contamination is concerned, no water sample was found contaminated with it.

**Table 3.** Trace and heavy metal content (mg $kg^{-1}$) of water samples collected from filtration plants in Rawalpindi region.

| | Total number | Mean | SD | C.V. | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Chromium | 12 | 0.16 | 0.35 | 224 | 0 | 1.26 |
| Lead | 12 | 0.01 | 0.04 | 236 | 0 | 0.12 |
| Zinc | 12 | 0.05 | 0.17 | 346 | 0 | 0.6 |
| Maganese | 12 | 0 | 0 | 0 | 0 | 0 |

All units are in mg $kg^{-1}$.

Dissolved oxygen is an important indicator of water quality. Dissolved oxygen is essentially affected by different parameters i.e. temperature, salinity, TSS and Altitude (Rudolph *et al.*, 2002). Water samples had dissolved oxygen ranging between 1.2 and 7.8 mg/L with mean value of 3.4 mg/L (Table 2). The highest concentration (7.8 mg/L) was found in Chandni Chowk and the lowest concentration (1.2 mg/L) was noted in Iqbal Town filtration plant which was within the satisfactory range suggested by WHO.

Sodium and Chloride contents were also below the critical values. Sodium content ranged from 45.7 to

130 mg/L while Chloride content ranged from 1.5 to 9.54 mg/L (Table 2). WHO limit of Na and Cl for drinking water is 250 mg/L for both. All water samples were safe so for as sodium and chloride contents were concerned.

The highest concentration of sodium (130 mg/L) was recorded in Saddar filtration plant and the lowest concentration (45.7 mg/L) in Shamsabad. On the other hand the highest concentration of chlorides (9.54 mg/L) was noted in Shamsabad and the lowest concentration (1.5 mg/L) was recorded in Saddar filtration plant.

*Zinc, manganese, lead and chromium content in water samples*

So for as trace metals are concerned in most of the water samples zinc was either below the detection limit or not detected at all. Only in one sample obtained from Faizabad showed zinc level at 0.625 mg/L (Table 3). Similarly, Mn was also not detected in all except one water sample. In this water sample Mn was recorded at 0.043 mg/L in Faizabad. In most of the water samples Pb was not detected. Only in two water samples taken from Chandni Chowk and Rehman Abad filtration plants, Pb was detected where it was 0.129 and 0.09 mg/L respectively.

**Table 4.** Drinking water quality guidelines.

| Parameter | Pak-EPA limit (mg $L^{-1}$) | WHO limit |
|---|---|---|
| pH | 6.5-8.5 | 6.5-8.5 |
| EC | 400 µS/$cm^{-1}$ | 400 µS/$cm^{-1}$ |
| Copper | 3 | 2 |
| Zinc | 5 | 5 |
| Chromium | 0.05 | 0.05 |
| Lead | 0.05 | 0.001 |
| Calcium | 75 | 75 |
| Magnesium | 50 | 5 |
| Nitrate | 50 | 50 |
| Hardness | 500 | 500 |

Acceptable limit of WHO for Pb in water is 0.01mg/L and Pak-EPA limit for Pb in water is 0.05. When compared with these limits, Pb content was very high which is not good for human health in the long run. Out of 12 water samples, Cr was detected in 8 samples (Table 3). Chromium concentration ranged from 0.03 to 1.26 mg/L. Acceptable limit of Cr for drinking water is 0.05 mg/L (WHO). Lead and Cr are among the heavy metals whose higher concentration is toxic to animals and plants (Azizullah *et al.*, 2011). Contaminated water is a main source of these heavy metals (WWF, 2007). In one study conducted in Azad Jammu and Kashmir (AJAK) it was estimated that around 80% patients in hospitals were due to water related diseases (Javaid *et al.*, 2008). Treating these patients also puts burden on national exchequer. Effects of Pb on health are wide ranging from disturbed metabolism to renal failure and death (Papanikolaou *et al.,* 2005). Human activities have main role in increasing the exposure to Pb in our environment. In Sialkot and Hattar which are famous industrial areas of Pakistan Pb was quite high in underground water (Manzoor *et al.,* 2006). In Hattar area average value of Pb of water samples was 0.26 mg/L while WHO acceptable limit for Pb in drinking water is 0.01 mg/L.

Chromium is used mainly in dyes and leather tanning industries. It usually occurs in two oxidation states $Cr^{+3}$ and $Cr^{+6}$ (Kabata *et al.,* 2011). $Cr^{+3}$ is considered a stable form and found in food (Dietary *et al.,* 2011). For human consumption $Cr^{3+}$ within the range of 25-30 µg/day is considered safe. However, $Cr^{+6}$ is considered toxic and carcinogenic as well (IARC 2012). Although in water samples from Kasur higher level of Cr has been reported (Tariq *et al.,* 2008) but

content in drinking water samples from Rawalpindi has not been reported previously. Knowing oxidation states of Cr is very important to ascertain the level of Cr toxicity. Chromium concentration in the water samples analyzed was higher than the permissible level. Further speciation of Cr is necessary to ascertain the level of problem.

**Conclusion**

It was concluded that 80% water samples were fit for drinking purpose. Only 20% water samples were unfit for drinking due to high Cr content.

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