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Full Length Research Paper

Water pollution: Major issue in urban areas

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Like most of developing countries urbanization and industrialization have not gone in pace with environmental pollution, resulting in numerous problems arising from environmental pollution. This is specifically true about water bodies wherein various toxic solid wastes, effluents and emission are being discharged, resulting in an excessive amount of toxic and hazardous metals in local ground water. Due to discharge of untreated industrial effluents in the sewage channels, the ground water quality is deteriorated to great extent therefore availability of healthy, clean and good quality drinking water is a matter of great concern in the urban areas. The extent of ground water contamination was evaluated in the third biggest city of Pakistan well known as Manchester of Pakistan that is Faisalabad. Water samples were collected from the hand pumps installed within the 10 m circumference of the sewage channels. These samples were analysed for pH, Total dissolved solids (TDS), hardness, alkalinity, sulphate (SO_4^{-2}), chloride (Cl^-), sodium (Na^+) and potassium (K^+) by following the standard methods described by the American society for testing and materials (ASTM, 1993). Furthermore, heavy metals ions like cadmium, chromium, copper, iron, lead, manganese, nickel and zinc were determined by varian AA-1445 series atomic absorption spectrophotometer (AOAC, 1984). Results revealed that in most of the cases water samples were not fit for drinking purposes when compared with the standard guide lines available for drinking waters.

Key words: Ground water contamination, drinking water, total dissolved solid, heavy metals.

INTRODUCTION

Clean water is not only the basic need of human being but it also has a great influence on the all aspects of human life (Ahmed, 2005; Dara, 1997, Snoeink and Tenkin, 1983; ASTM, 1981; Hawkins, 1976). Without water it would not have been possible to sustain life on this planet. Deprivation of water will kill an object much earlier than deprivation of food (Chattarjee, 1983). It has been estimated that man can survive for about 20 days without food but start struggling for life in the absence of water just after one day (Srivastava, 1995). Being the most drinking fluid water is also a potential source of transmitting diseases especially in developing counties. According to World Health Organization (WHO) survey 80% of all diseases in developing countries are water born (Tebbutt, 1983).

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The total quantity of water on earth is estimated to be 1.4 trillion cubic meters. Of this less than 1% water present in rivers and ground water resources is available to meet our requirements (Qadeer, 2004). The sources of fresh water in Pakistan are glaciers, rivers and lakes but due to the shortage of rains and snowfall Pakistan is suffering from water shortage. To overcome this situation, there is a need to use ground water. It is a valuable natural resource for various human activities (Prasad and Narayana, 2004). Natural water always contains dissolved and suspended substances of organic and mineral origin. The pollution of ground water is a major concern, firstly because of increasing utilization for human needs and secondly because of the ill effects of the increased industrial activity (Jain et al., 2005).

Faisalabad, which is densely, populated third biggest city of Pakistan. Due to tremendous increase in population growth, the demand for water has been increasing every year. Along with other sources of water,

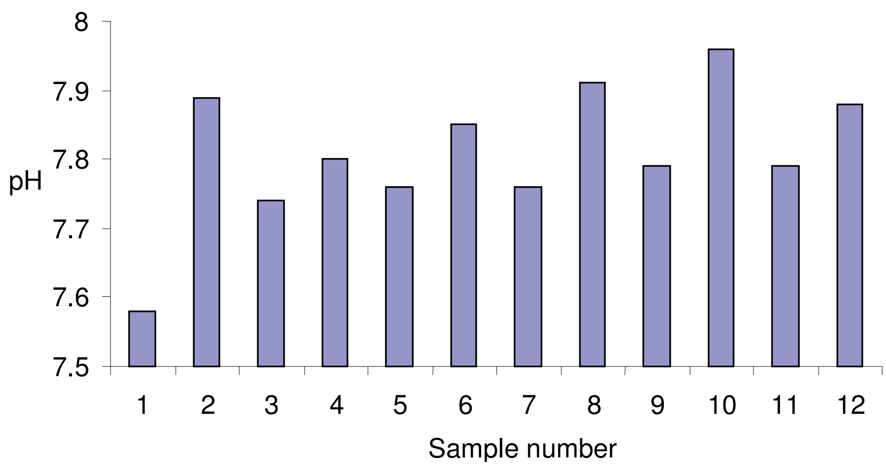

Figure 1. pH of ground water.

ground water is also being used for drinking purpose. Faisalabad being the Manchester of Pakistan with a large number of industrial units, which use large volumes of water in their manufacturing and supporting operations. This rapid industrialization has created multifarious problems for the disposal of industrial wastes. Especially the present free style way of disposal of the untreated industrial effluents into sewage channels and natural water-bodies results in serious surface and ground water contamination as only few industries are equipped with treatment plants (Nabi et al., 2001). According to a rough estimate, 9,000 million gallons of waste water is daily discharged into the water bodies by the different industries in Pakistan (Saleemi, 1993). These effluents contain not only toxic metal ions but also other pollutant such as toxic chemicals, metallic compounds and biologically oxidize-able metals. These effluents are affecting living being as well as the ecosystem (Qadeer, 2004).

The composition of ground water over which and through which it flows after falling to the earth through rains, determines the additional impurities that it absorbs. Ground water usually contains more dissolved minerals but less suspended matter than surface water because it filtered out during percolating through the earth. Weather may be the source, water having impurities and water of specific quality is required for various uses like irrigation, drinking, cooling etc (Sastry et al., 1995). Present rearch work was conducted with objective to evaluate the suitability of the ground water for human consumption.

MATERIALS AND METHODS

In order to evaluate the extent of ground water quality used for drinking purposes, sampling was done from the hand pumps installed within 10 m circumference from the sewage channels passing through the urban areas of Faisalabad, Pakistan. Sampling was done in the properly cleaned plastic jars. These plastic sampling jars were rinsed three times before the water samples were collected. Total twelve water samples were collected from the twelve different locations. Immediately after collection, the samples were analyzed for pH, total dissolved solids (TDS), hardness, alkalinity, sulphate (SO_4^{-2}), chloride (Cl^-), sodium (Na^+) and potassium (K^+) by following the standard methods described by the ASTM, 1993. The concentration of the heavy metals ions like cadmium, chromium, copper, iron, lead, manganese, nickel and zinc were determined by varian AA-1445 series atomic absorption spectrophotometer (AOAC, 1984) by properly calibrating the equipment with standards for précised results.

RESULTS AND DISCUSSION

Analytical results of the different parameters of drinking water are discussed.

pH of drinking water

Although no health based guideline is proposed for pH but some times, eye irritation and other skin disorders are associated with values of pH greater than 11. The water having pH range 10 to 12.5 can cause hair to swell and in sensitive individuals gastrointestinal irritation may occur. The lower values will also lead to the similar effect (Khan and Ahmad, 2001). No such problems were found in ground water samples collected from different areas of Faisalabad (Figure 1). Because their pH values were within the range, which World Health Organization (WHO) has recommended for drinking water that is, 6.50 to 8.50. Similar results were reported by Jain et al. (2005), Khan and Bangash (2001), Bangash and Khan (2001) and Khan and Ahmed (2001) in their studies on the underground water quality in the urban areas.

Total dissolved Salts (TDS)

Total dissolved salts (TDS) comprise mainly of inorganic salts (bicarbonates, chlorides and sulphates of calcium,

Table 1. Chemical analysis of ground water samples.

Parameter	Unit	Minimum	Maximum	Mean
pH	-	7.58	7.96	7.81
TDS	mg/L	1190	2415	1754
Hardness	‘	321	737	458
Alkalinity	‘	476	648	576
Sulphate	‘	241	570	354
Chloride	‘	171	380	290
Sodium	‘	216	489	382
Potassium	‘	32	60	48
Cadmium	‘	0.01	0.02	0.02
Chromium	‘	0.12	0.17	0.15
Copper	‘	0.10	0.40	0.28
Iron	‘	0.24	0.45	0.34
Manganese	‘	0.08	0.38	0.18
Lead	‘	0.00	0.01	0.00
Nickel	‘	0.04	0.10	0.06
Zinc	‘	0.24	0.80	0.54

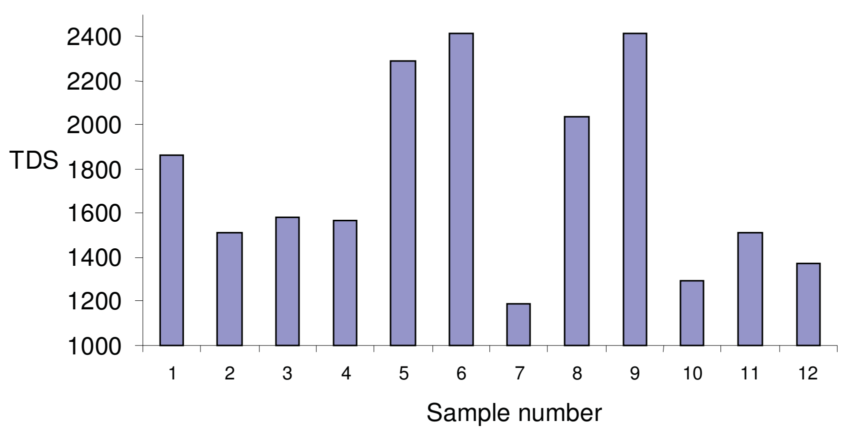

Figure 2. TDS concentration (mg/L) in ground water.

magnesium, potassium and sodium) and some small amounts of organic matter that are soluble in water. In other words, the total dissolved solids concentration is the sum of the cations and anions in the water. Therefore the total dissolves solids test provide a measure of the amount of dissolved ions but does not tell us about the nature of ions. Total dissolve salts in drinking-water originate from natural sources, sewage, urban run off, industrial wastewater and chemical used in the water treatment process and the nature of the piping or hardware used to convey the water, that is, the plumbing. Table 1 indicates the TDS values are in the range of 1190 to 2415 mg/L. All the water samples have TDS level above the permissible limits recommended by WHO (1000 mg/L) as shown in Figure 2. High level of TDS indicates high concentration of dissolved ions, which render water non-potable, corrosive and of salty or brackish taste. Shakirullah et al. (2005), Ahmad (2005), Khan and Bangash (2001) and Jain et al. (2005) in their studies about drinking water quality, expressed similar views. Furthermore it has also investigated that it has positive correlation (Table 2) with all other cations and anions determined. Findings of the present study were in agreement with the results of the survey conducted by Samina et al. (2004) and Jain et al. (2005) in their studies.

Hardness

Hardness values in ground water samples were in the range of 321 to 737 mg/L (Table 1).The maximum limit of total hardness recommended by WHO and American Public Health Association (APHA) are 500 and 250 mg/L

Table 2. Correlation among various parameters of chemical analysis.

	pH	TDS	Hardness	Alkalinity	SO_4	Cl	Na	K	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn
pH	1.00	-0.16	-0.01	0.17	-0.34	-0.34	0.11	0.20	-0.39	-0.20	-0.11	-0.34	-0.02	-0.10	-0.12	-0.10
TDS		1.00	0.81	0.62	0.86	0.81	0.41	0.43	0.39	0.54	0.45	0.58	0.04	0.53	0.32	0.53
Hardness			1.00	0.56	0.71	0.51	0.22	0.28	0.46	0.68	0.63	0.44	0.11	0.51	0.14	0.66
Alkalinity				1.00	0.37	0.40	0.07	0.84	-0.06	0.11	0.26	0.40	0.14	0.50	0.50	0.64
SO_4					1.00	0.80	0.29	0.26	0.34	0.58	0.32	0.82	0.12	0.47	0.43	0.44
Cl						1.00	0.68	0.36	0.19	0.44	0.27	0.72	0.22	0.34	0.26	0.29
Na							1.00	0.09	-0.01	0.11	0.08	0.19	0.08	0.11	-0.17	-0.19
K								1.00	-0.15	0.03	0.23	0.36	0.47	0.53	0.63	0.52
Cd									1.00	0.42	0.60	0.18	-0.02	0.56	0.17	0.55
Cr										1.00	0.65	0.34	0.36	0.14	-0.19	0.38
Cu											1.00	0.13	0.61	0.58	0.00	0.67
Fe												1.00	0.19	0.48	0.66	0.47
Mn													1.00	0.31	0.14	0.33
Ni														1.00	0.68	0.67
Pb															1.00	0.54
Zn																1.00

respectively. Most of the water samples have hardness with in the permissible limits defined by WHO but higher than APHA limits (Figure 3). In groundwater, hardness is mainly due to carbonates, bicarbonates, sulphates and chlorides of Ca and Mg. Hardness showed negative correlation with pH and positive correation with other parameters (Table 2). The results are in agreement with the findings of Trivedi (1988), Jain et al. (2005) and Samina et al. (2004). High level of total hardness may cause diarrhea, gas trouble, kidney stone, heart problems, etc (Smith and Crombir, 1987; WHO, 1996).

Alkalinity

Alkalinity of water samples was in the range of 476 to 648 mg L^{-1} (Table 1), where as WHO has suggested the permissible limit of 500 mg/L. Beyond the permissible limit, alkalinity causes many problems like hardness of kidney stone, gas trouble, sever irritation of the eye, skin and mucus membrane. (Bangash and Alam, 2004; John, 1990). Alkalinity showed positive correlation with TDS, TH, Cl, SO4, Na, K and other heavy metals except Cd (Table 2). The results are in agreement with the findings of Devi et al. (2003), Jain et al. (2005) and Samina et al. (2004) (Figure 4).

Sulphate (SO_4)

Sulphate is one of the least toxic anions. However, catharsis, dehydration and gastro-intestinal irritation have been observed at high concentration (Ellenhorn and Barceloux, 1988). The permissible level for sulphate recommended by WHO is 250 mg/L .The Sulphate content of water varies from sample to sample (Figure 5) and ranged from 241 to 570 mg/L (Table 1). In most of the cases sulphate level is above the critical level and may cause above-mentioned diseases. Shakirullah et al. (2005) reported similar suggestions in their study on underground water quality for drinking. Sulphate showed positive correlation (Table 2) with TDS, hardness, alkalinity, SO4, Cl, Na, K and other metal ions underinvestigation (Table 2). The results are in agreement with the previous work conducted by Samina et al. (2004).

Chloride

Chloride is normally associated with salty water. Table 1 show that the chloride level of water

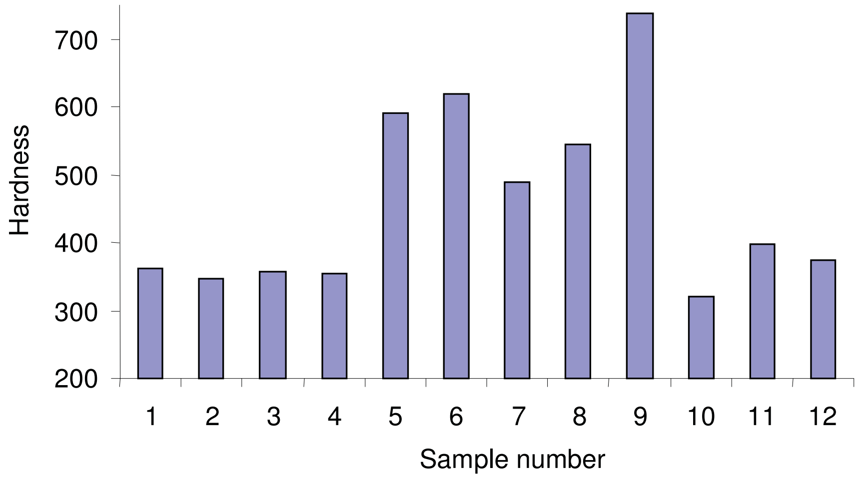

Figure 3. Hardness (mg/L) in ground water.

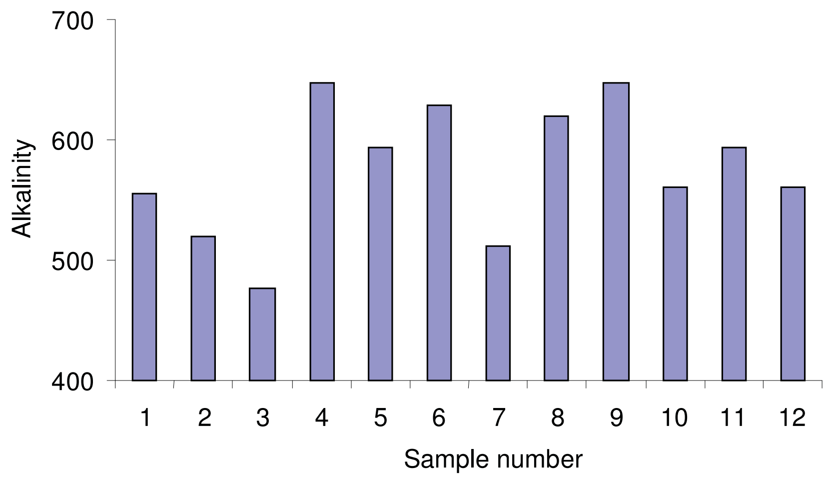

Figure 4. Alkalinity (mg L^{-1}) in ground water.

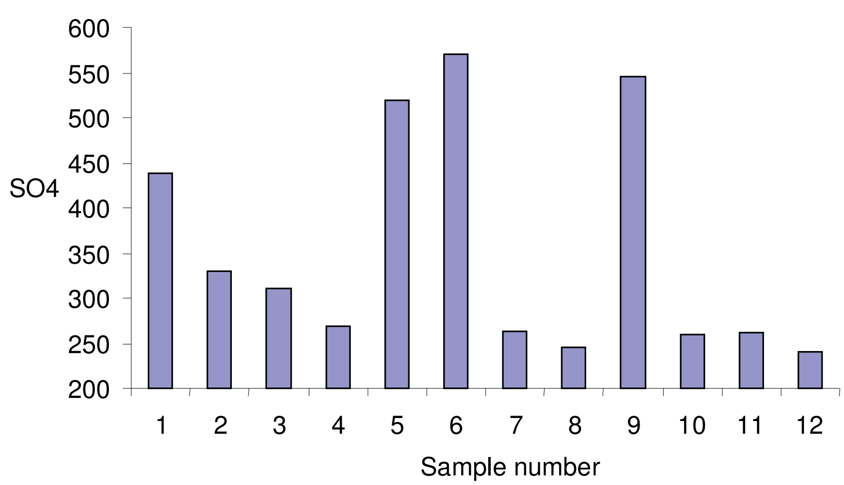

Figure 5. SO_4 concentration (mg/L) in ground water.

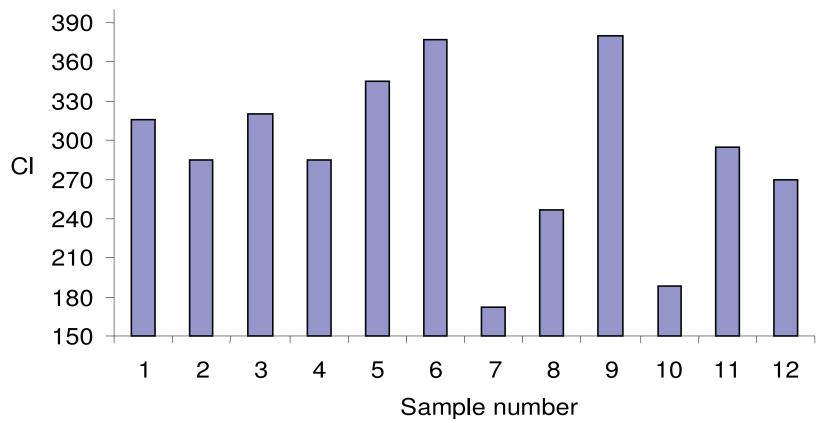

Figure 6. Cl concentration (mg/L) in ground water.

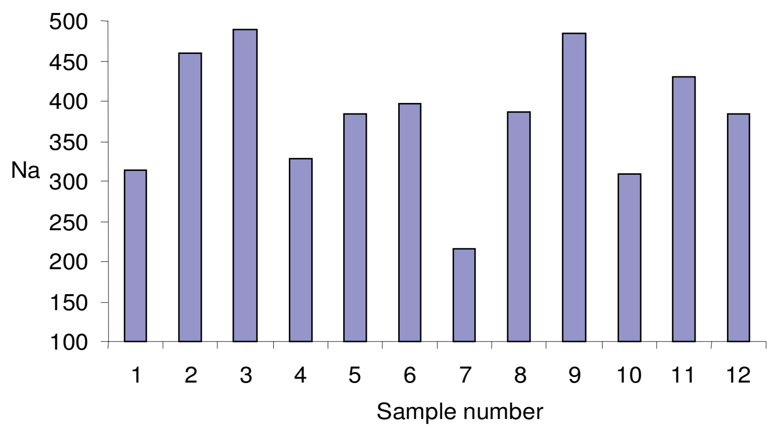

Figure 7. Na concentration (mg/L) in ground water.

samples was in the range of 171 to 380 mg/L. Most of the samples have chloride level above the WHO limit that is, 250 mg/L. A high level of chloride may cause gastrointestinal problems, irritation, diarrhea and dehydration (Shakirullah et al., 2005; WHO, 1996, Qadeer, 2004). Excessive level of chloride also imparts taste problem (Khan, 2001; Jain et al., 2005). In this study chloride showed negative correlation with pH and positive correlation with other parameters. The results are in agreement with the previous findings of Jain et al. (2005) and Samina et al. (2004). Marechal et al. (2006) in their studies of similar nature have also reported higher chloride concentration in ground water due to sewage water (Figure 6).

Sodium

Sodium was found in the water samples in the range of 216 to 489 mg/L (Table 1). Only one sample showed lower concentration than the maximum acceptable concentration that is, 250 mg/L, while in all other samples it is above the critical level. Sodium in drinking water is not a health concern for most of the people, but may be an issue for someone with heart diseases, hypertension, kidney disease, and circulatory illness or on sodium controlled diet. Studies have shown that reducing salt intake will lower blood pressure in people with hypertension, but can not be conclusively inferred that increased sodium intake will cause hyper tension (Radojevic and Bashkin, 1999). Sodium showed significantly positive correlation ($r = 0.77$) with potassium and results are in accordance with the findings of Jain et al. (2005) and Samina et al. (2004) (Figure 7).

Potassium

The potassium values of the water samples were in the range of 32 to 60 mg/L (Figure 8). According to WHO the safe limit of potassium is 12 mg /L. Excessive quantity of potassium in the drinking water may cause dehydration

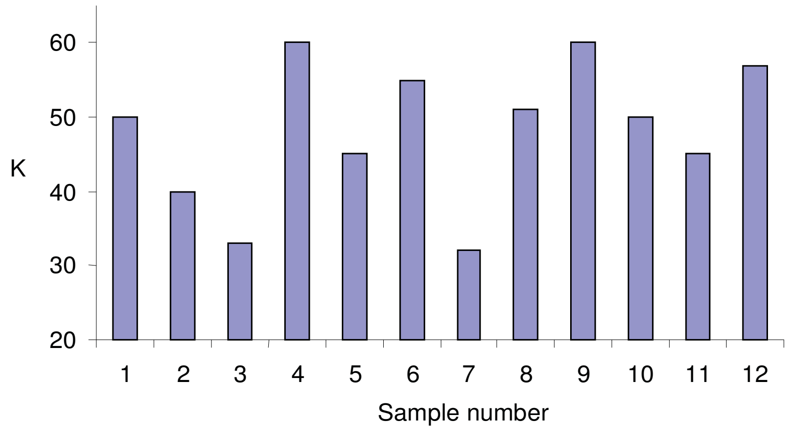

Figure 8. K concentration (mg/L) in ground water.

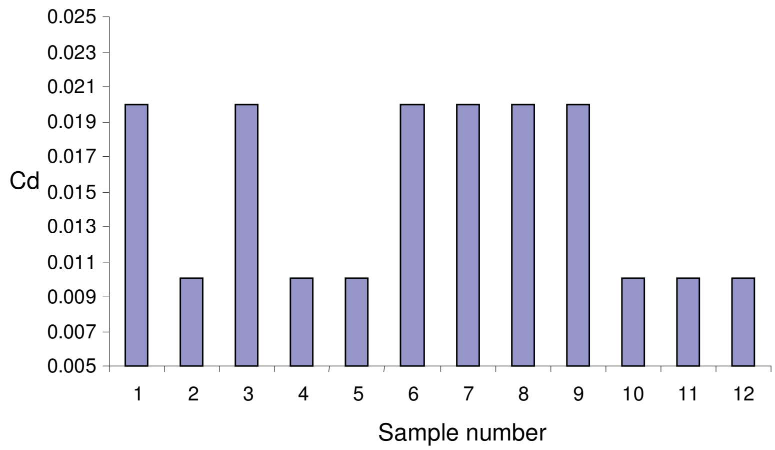

Figure 9. Cd concentration (mg/L) in ground water.

(Radojevic and Bashkin, 1999). Similarly higher values in ground water have been reported by Baloch et al. (2000) and Samina et al. (2004).

Cadmium

The maximum allowable concentration of cadmium in drinking water is 0.005 ppm defined by WHO. The samples analyzed have cadmium concentration ranges from 0.01 to 0.02 ppm (Table 1). All samples have Cd concentration above the critical level (Figure 9). Higher concentration in drinking water may cause kidney damage (Qadeer, 2004; WHO, 1996; APHA, 1995). Cadmium showed negative correlation with pH and lead. Results are in agreement with the previous investigation conducted by Samina et al. (2004).

Chromium

Some people who use water-containing chromium well in excess of the recommended maximum concentration level over many years could experiences allergic dermatitis (Qadeer, 2004; WHO, 1996). World Health Organization limit for Chromium is 0.1 ppm for drinking water. The chromium level was found well above the critical level suggested by WHO (Figure 10), which clearly indicates the ground water contamination. Similar results were reported by WHO (1996), APHA (1995) and Qadeer (2004).

Copper

Deficiency of copper causes anemia, loss of hair pigment, growth inhibition, and loss of arterial elasticity. Concentration of 1 ppm is also a taste threshold for the majority of people (Elenhorn and Barceloux, 1988). Copper is rarely found in the natural water. Most water contamination by this element happens in the water delivery system or by untreated industrial wastewater

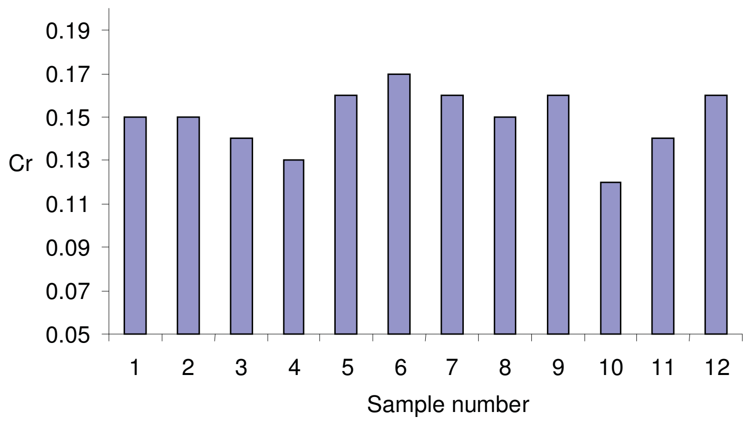

Figure 10. Cr concentration (mg/L) in ground water.

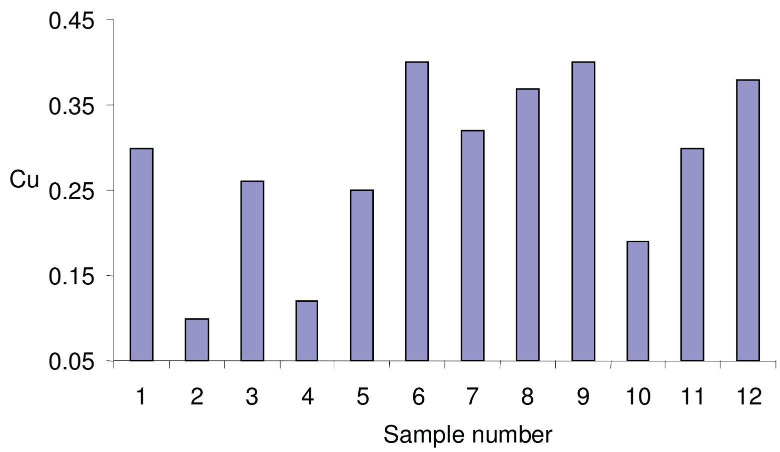

Figure 11. Cu concentration (mg/L) in ground water.

pollution. The maximum permissible limit for copper recommended by WHO is 3 ppm. Data presented in Table 1 and graphed in Figure 11 shows that the concentration of copper in the water samples analysed varied in the range of 0.10 to 0.40 ppm. Similarly lowere concentration in ground water was reported by Samina et al. (2004), Khan and Ahmed (2001) in their studies.

Iron

The observed concentration of iron in samples as summarized in Table 1 shows that the concentration varies from 0.24 to 0.45 ppm. The permissible limit of iron is 0.30 ppm in drinking water defined by WHO. Iron limits for drinking water are based on aesthetic parameters rather than on toxicity (Shakirullah et al., 2005). The major disadvantage of the presence of iron in water is that it increases the hazard of pathogenic organism because most of these organisms need iron to grow (Khan and Ahmed, 2001). Most of the samples in our study have Fe concentration above critical level while Khan and Ahmed (2001) also observed higher concentration of iron in the ground water in Karachi (Figure 12).

Manganese

It is essential for human health; inadequate uptake may cause skeletal abnormalities, reproductive deficits, defects in lipid and carbohydrates metabolism while higher level may cause lethargy, increased muscle tone tremor and mental disturbances (WHO, 1996). It is observed from Table 1 that the concentration of Mn is ranged from 0.08 to 0.38. The permissible limit of Mn is 0.05 pmm defined by WHO. In all the samples (Figure 13) Mn level was found above the critical level.

Lead

The lead values of the water samples lie between 0.00 to

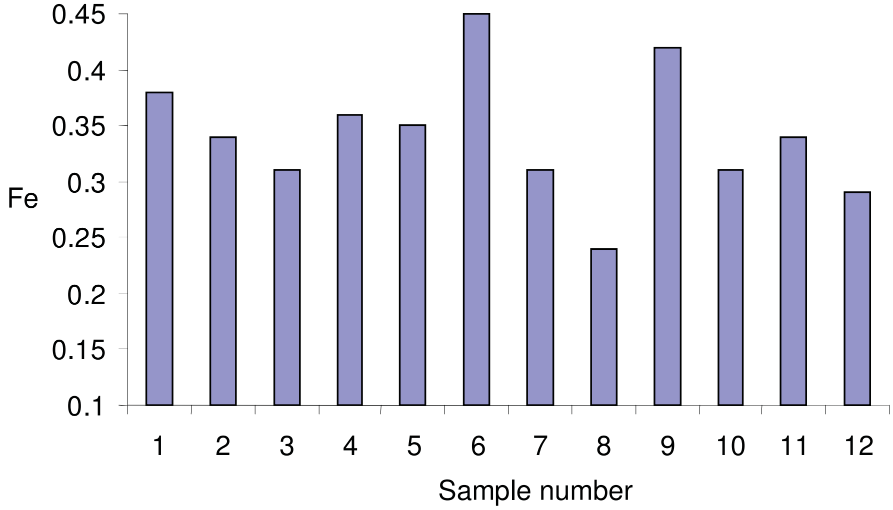

Figure 12. Fe concentration (mg/L) in ground water.

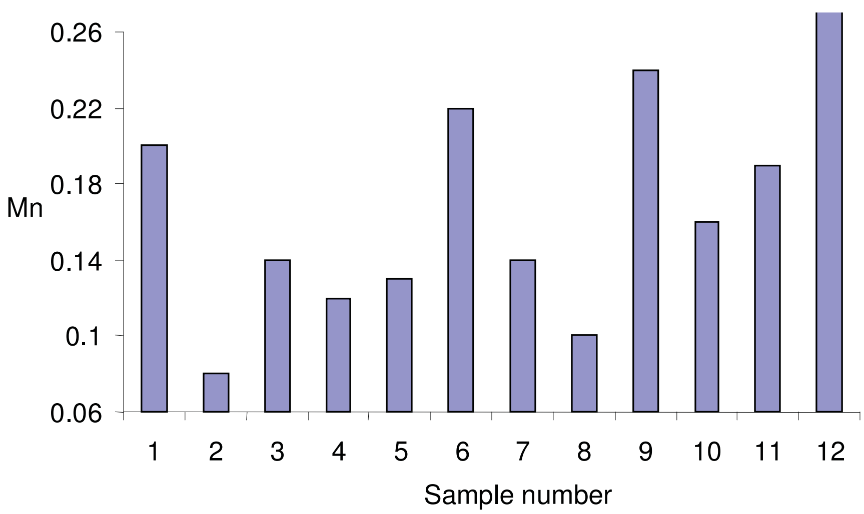

Figure 13. Mn concentration (mg/L) in ground water.

0.01 ppm. According to WHO permissible level of lead in drinking water is 0.015 ppm. Higher concentration of lead in drinking water may cause delay in physical or mental development in infants and children, while in adults may cause kidney problem and high blood pressure (Qadeer, 2004). In all the samples Pb concentration was found within the permissible level (Figure 14).

Nickel

Its concentration in water samples were in the range of 0.04 to 0.10 (Table 1).The permissible limit of nickel in drinking water is 0.1 ppm. It is evident from the Figure 15 that in most of the cases the observed values were below the permissible level. Similarly, lower concentrations were observed by Samina et al. (2004) in their studies on ground water. Higher concentration may cause different diseases like, vomiting, nausea, abdominal discomfort, headache, cough and shortness of breath. (WHO, 1996).

Zinc

The zinc deficiency results into retardation of growth, anorexia, lesions of the skin and impaired development and function of reproductive organs. On the other side when the level of zinc is exceeded then it causes fever, depression, malaise, cough, vomiting, salivation and headache (WHO, 1996). The level of Zn in the water

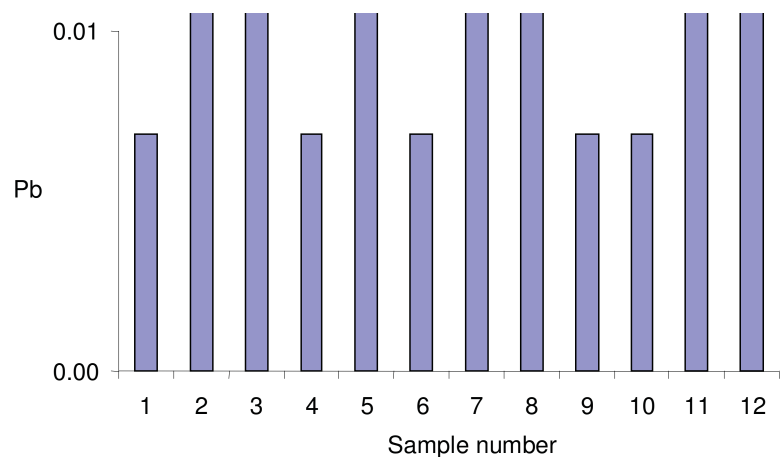

Figure 14. Pb concentration (mg/L) in ground water.

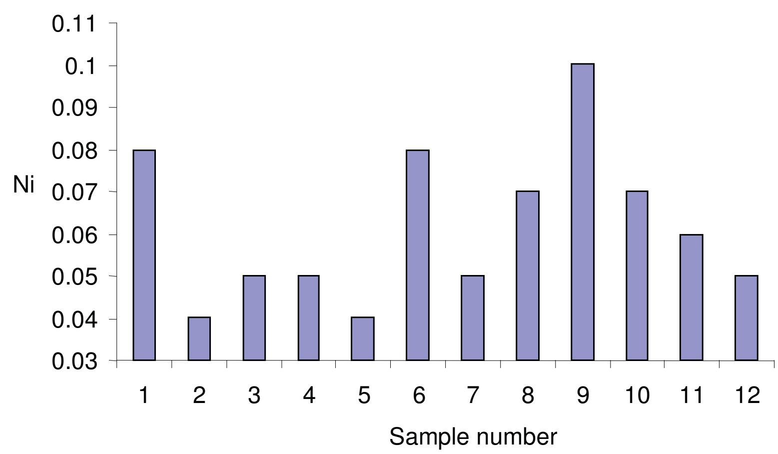

Figure 15. Ni concentration (mg/L) in ground water.

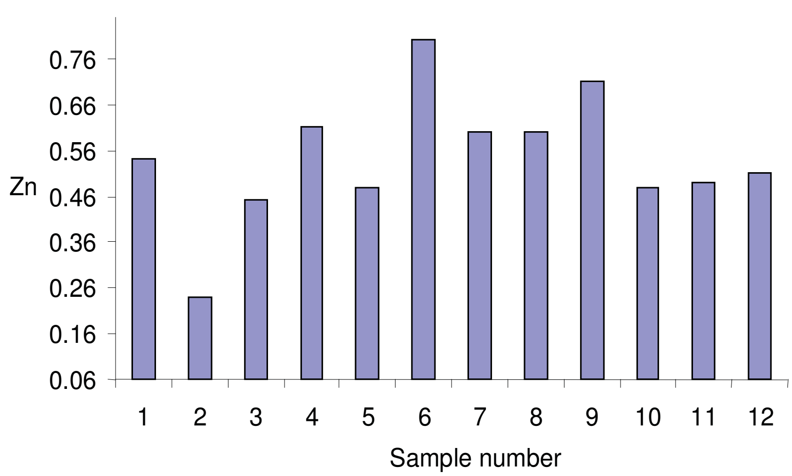

Figure 16. Zn concentration (mg/L) in ground water.

samples was observed in the range of 0.24 to 0.80 ppm.The recommended limit of WHO is 3.00 ppm in drinking water while in all the samples (Figure 16). Zn concentration is well below this level.

Conclusion

The data indicates that the ground water used for drinking purpose near sewage channels is highly polluted and not suitable for human consumption. Therefore, alternate source of drinking water must be explored especially the pumping of good quality drinking water near rivers for the supply to the community living in the areas where this problem persists. Furthermore, industrial water must be treated, before throwing in to the channels carrying domestic effluents, because it is a major source of ground water pollution in the area under study. Moreover hand pumps must be installed atleast twenty meters away from the channels in order to minimize the seepage impact on the pumped water used for drinking.

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