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Chemical Characteristics of Drinking Water of Peshawar

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Abstract: Ninety drinking water samples of fifteen each from three urban and three rural areas of Peshawar were collected and analyzed for their heavy metals, minerals, SO_4, NO_3 and Cl. In the urban area were Hayatabad, City and Sadder while from rural area Shikhmohamadi, Palosi and Jagra. Among the heavy metals and minerals Pb, Cr, Fe, Zn, Mn, Ca, Cu and Mg were determined by atomic absorption spectrophotometer, Na and K by flame photometer, Cl by titration method, SO_4 by spectrophotometer and NO_3 by nitrogen analyzer. The mean value of Pb, Cr, Fe, Zn, Cu and Mn among different locations were, 0.15±0.11, 0.21±0.05, 0.68±0.15, 0.09±0.14, 0.11±0.03 and 0.01±0.01 mg/L respectively. The mean value of Na, Mg, K and Ca were 26.61±3.70, 23.47±4.24, 3.11±1.77 and 40.96±16.94 mg/L respectively. For SO_4, NO_3 and Cl mean value 12±6.54, 5±1.26 mg/L and 14±4.90 mg/L respectively. Minerals content result obtained indicated that their level in different locations were in safe level as recommended by WHO and for heavy metals they are above the safe limit as recommended by WHO. Hence considered unfit for drinking purpose and it was concluded that the water from Peshawar region should be checked and monitored regularly in order to omit all possible sources of contamination or to reduce it.

Key words: Drinking water, heavy metals, minerals, contamination

INTRODUCTION

Water is clear, colorless, odorless and tasteless liquid, essential for most plant and animal life and the most widely used of all solvents. Freezing point 0°C (32°F); boiling point 100°C (212°F); specific gravity (4°C) 1.0000; weight per gallon (15°C) 8.338 pounds (3.782 kilograms).

Water is second to oxygen as being essential for life. People can survive days, weeks, or even longer without food, but only about four days without water. The average adult consumes and excretes about 2.5-3 quarts of water a day. Some of this water is supplied through foods but most is consumed through beverages. It is generally recommended that adults consume 6-8 cups (48-64 ounces) of liquids daily.

Water makes up about 60% of the human body Most of the living tissue of a human being is made up of water; it constitutes about 92% of blood plasma, about 80% of muscle tissue, about 60% of red blood cells and over half of most other tissues. It is also an important component of the tissues of most other living things (Turgut *et al*., 2005).

It covers some 70% of the earth's surface, with only 3% being from fresh water sources. With the world population growing and the increasing pollution of our natural resources, we are facing a water crisis. The World Health Organization has estimated that over 1 billion people lack access to safe drinking water and about 4000 children die every day from water borne disease (Virkutyte and Sillanpa, 2006).

As world population grows, drinking water is becoming increasingly scarce. Even in countries with sufficient supplies, this resource is often contaminated, especially in the world's threshold and developing nations. There are 1.2 billion people who do not have enough drinking water and 2.4 billion who are not connected to a sewage system.

Polluted water has direct effect on human health while sewerage and industrial effluents, have indirect effect through consumption of foodstuffs being irrigated with such type of discharge. According to World Health Organization more than 80% human diseases are water born. In developing countries 80% of the population has not easy excess to pure drinking water and more than 5 million human being die with and early death annually as a result of illness linked to unsafe drinking water unclean domestic environments and improper excreta disposed. Water pollutants mainly consist of heavy metals, microorganism, fertilizer and thousand of toxic organic compounds (WHO, 1999). Heavy metals consist of Cd, Cr, Cu, Pb, Ni, Fe, Mn, Hg, Zn, Al, Se as well as metals of group III and IV, which have toxic effect on human physiology. Along with the heavy metals the next most important pollutants are microorganisms. Surface and ground water contains bacteria, protozoa and other synthetic microorganisms. These affect water quality by assimilating NO_3, CO_2 and also solubilize some heavy metals in water. These also produce toxicants in ground water. They cause many epidemic diseases in human (Khan *et al*., 2000).

More than 2.6 billion people-forty percent of the world's population-lack basic sanitation facilities and over one billion people still use unsafe drinking water sources. As a result, thousands of children die every day from

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diarrhoea and other water-, sanitation- and hygiene-related diseases and many more suffer and are weakened by illness.

The World Health Organization (WHO, 1972-73) estimates that 500 million diarrhea cases reportedly take place each year in children less than five years in Asia, Africa and Latin America. The extent of enteric diseases in different areas depends upon the extent to which water is exposed to contamination. The incidence of typhoid fever, bacillary dysentery, infectious hepatitis and other enteric infections are common and are transmitted through contaminated water. Cholera is still a wide spread water borne disease in some developing countries. There are numerous other diseases that are transmitted through polluted water. It has been shown that cancer may be caused by the accumulation of certain materials carried out by water to human organs (DAWN, 1989).

The excess of cadmium accumulated in the kidney causes hypertension as is evident from study conducted on animals. The deficiency of chromium in drinking water favour atherosclerotic diseases in human. The compounds of chlorobenzenes and chlorophyll's may affect taste and odor of water.

Pakistan's current population of 141 million is expected to grow to about 221 million by the year 2025. This increase in population will have direct impact on the water sector for meeting the domestic, industrial and agricultural needs. Pakistan has now essentially exhausted its available water resources and is on the verge of becoming a water deficit country. The per capita water availability has dropped from 5,600-1,000 m^3. The quality of groundwater and surface-water is low and is further deteriorating because of unchecked disposal of untreated municipal and industrial waste water and excessive use of fertilizers and insecticides. Water quality monitoring and information management is lacking, even though it's crucial to any water quality improvement program (Shakirullah *et al*., 2005).

It is estimated that by 2025 world water consumption will rise by 40%. This is why investments are urgently needed in the entire water infrastructure around the world, especially in mega cities. An additional main user of water is industry, whose plants can only be kept running with the aid of a wide range of process waters (Sidhu and Warner, 2003).

The purpose of present study to observed the physicochemical and bacteriological characteristics of Peshawar.

The objective of the study was:

- Determine mineral (Na, K, Ca, Mg, Mn, Fe, Zn, Pb, Cr, Cl, SO_4, NO_3) contents in drinking water.

MATERIALS AND METHODS

The water samples were tested for chemical analysis. Drinking water samples from different areas of Peshawar were tested for heavy metals, minerals, SO_4, NO_3 and Cl, in order to evaluate its quality. Urban and Rural areas of Peshawar were selected randomly. Urban area constitutes Hayyatabad, Sadder and City and while rural constitutes Sheikh Mohammadi, Jagra and Palosi.

From each location 15 water samples were collected in one liter capacity plastic bottles for chemical analysis. Before sampling the bottles were washed with detergents, followed by tape water and finally several time with distilled water. The water at the samples site was allowed to flow for some time then the bottles were rinsed two to three times by this water and one liter was taken as sample from drinking water. The samples were properly tagged indicating code. These samples were air tightened and stored in refrigerator.

Chemical analysis

Heavy metals and minerals: 100 ml water sample was taken and were analyzed for heavy metals. Among the heavy metals and minerals Pb, Cu, Zn, Fe, Cr, Mg, Mn and Ca were determined by atomic absorption spectrophotometer (model parkin Elmer 2380) while Na and K were determined by flam photometer.

Determination of SO_4: 10 ml of samples was added with 1 ml of 6 N HCl followed by 5 ml 70% sorbitol mixed and added with 1 g $BaCl_2$ and again mixed. Reading was noted at 470 nm wavelength on spectrophotometer. Standard were prepared with the same procedure and SO_4 were determined by Turbedemetric method (AOAC 2003 method no 973.57).

Determination of NO_3: 20 ml of water sample was distilled with MgO+DA which was collected in 5 ml Boric acid mixed indicator and it was then titrated against 0.005 M HCl and NO_3 were determined by Kjeldahal method (AOAC 2003 method no 973.48).

Determination of Cl: 10 ml sample was taken and two to three drops of phenolphthalein indicator and titrated against 0.05 N $AgNO_3$ till the disappear of pink color and Cl were determined by Mercuric Nitrate method (AOAC 2003 method no 973.51).

Statistical analysis: Physical, chemical and becterlogoical data were checked by using Epi-info statistical software. Descriptive statistical analysis was carried out in order to check the mean, standard deviation and range in collected data. Difference between urban and rural was checked by F-test (ANOVA).

RESULTS AND DISCUSSION

Water sample collected from Peshawar valley were analyzed for their chemical characteristics. The heavy metals, minerals, SO_4, NO_3 and Cl were determined. Among the heavy metals Pb, Cu, Zn, Fe, Cr, Mn in minerals Na, K, Mg and Ca were analyzed.

Table 1: Minerals content of water sample

Area	Na mg/L	K mg/L	Mg mg/L
		Mean±SD	
Total urban (n = 45)	24.89±3.77	2.71±0.59	20.67±3.81
Hayatabad (n = 15)	26.87±4.63	2.73±0.46	16.46±0.58
Sadder (n = 15)	23.53±2.85	2.80±0.77	21.21±3.27
City (n = 15)	24.27±2.94	2.80±0.77	24.33±0.96
Total rural (n = 45)	28.33±2.72	3.51±2.38	26.27±2.39
Sheikh Mohammadi (n = 15)	26.13±1.13	5.87±2.90	26.34±1.78
Jagra (n = 15)	29.60±1.18	2.20±0.41	27.28±1.48
Palosi (n = 15)	29.27±3.58	2.47±0.52	25.20±3.19
Grand total (n = 90)	26.61±3.70	3.11±1.77	23.47±4.24

Table 1 represent the mineral content of water sample. Among the mineral content Na, K and Mg were analyzed for their mineral chemical characteristics and then compared with WHO standards

Sodium in drinking water: Sodium was found in water sample of Peshawar valley in the range of 17.00-33.00 mg/L with Total mean Na value 26.61 mg/L which is lower than the WHO maximum acceptable concentration i.e. 250 mg/L, mean value of Na for Hayatabad, Sadder, City, Sheikh Mohammdi, Jagra and Palosi were 26.87, 23.53, 24.27, 26.13, 29.60 and 29.27 mg/L recorded respectively.

Na in drinking water is not of a health concern for most people. But may be an issue for someone with heart disease, hypertension, kidney disease, circulatory illness or on sodium controlled diet. Studies have shown that reducing salt intake will lower blood pressure in people with hypertension but it can be conclusively inferred that increased sodium will cause hypertension (Radojevic, 1999).

It is unlikely that sodium alone is carcinogenic. However, a high-salt diet may enhance the carcinogenic potency of chemicals such as *N*-methyl-*N*'-nitro-*N*-nitrosoguanidine in drinking water by causing irritation of the gastroduodenal tract, thus increasing the exposure of epithelial cells to the carcinogen and resulting in an increased incidence of gastric tumours (Takahashi, 1983). Although it is generally agreed that sodium is essential to human life, there is no agreement on the minimum daily requirement. However, it has been estimated that a total daily intake of 120-400 mg will meet the daily needs of growing infants and young children and 500 mg those of adults (NRC Washington, 1989).

In general, sodium salts are not acutely toxic because of the efficiency with which mature kidneys excrete sodium. However, acute effects and death have been reported following accidental overdoses of sodium chloride. Acute effects may include nausea, vomiting, convulsions, muscular twitching and rigidity and cerebral and pulmonary oedema. Excessive salt intake seriously aggravates chronic congestive heart failure, and ill effects due to high levels of sodium in drinking-water have been documented. (Department of National Health and Welfare, 1992).

The effects on infants are different from those in adults because of the immaturity of infant kidneys. Infants with severe gastrointestinal infections can suffer from fluid loss, leading to dehydration and raised sodium levels in the plasma (hypernatraemia), permanent neurological damage is common under such conditions. Addition of cows' milk or tap water containing high levels of sodium to solid food may exacerbate the effects (Sax *et al*., 1985) Whereas reducing the sodium intake can reduce the blood pressure of some individuals with hypertension, this is not effective in all cases. In addition, some data for both humans and animals suggest that the action of sodium may be at least partly modified by the level of the accompanying anion as well as that of other cations. Although several studies suggest that high levels of sodium in drinking-water are associated with increased blood pressure in children.

Although there is an association between hypertension and certain diseases, such as coronary heart disease, genetic differences in susceptibility, possibly protective minerals (potassium and calcium) and methodological weaknesses in experiments make it difficult to quantify the relationship and sodium in drinking-water generally makes only a small contribution to total dietary sodium. No firm conclusions can therefore be drawn at present as to the importance of sodium in drinking-water and its possible association with disease.

Potassium: Potassium ranks seventh among the elements in order of abundance, yet its concentration in most drinking water reached to the range of 2.00-9.00 mg/L with total mean K value 3.11 mg/L of Peshawar valley which is in recommended level of WHO i.e. 12.00 mg/L. mean value of K for Hayatabad, sadder, City, sheikh Mohammdi, Jagra and Palosi were 2.60, 2.73, 2.80, 5.80, 2.20 and 2.47 mg/L.

Excessive loss of extra cellular fluid may result in potassium deficiency. The loss may be due to vomiting, diarrhea, excessive diuresis or prolonged malnutrition. The chief features of deficiency are muscular weakness and mental apathy. In hypokalemia cardiac failure can result from depletion of ionized potassium in heart muscle (Vogel *et al*., 1999).

In hyperkalemia the serum level is elevated, resulting from kidney failure to clear ionized potassium. The symptoms are mental confusion, numbness of extremities, poor respiration and weakening of heart action. The strongest epidemiological argument in favor of a water magnesium effect was provided by Dr. Paul Hunter based upon analytical studies in Taiwan (by Dr. Chun-Yuh Yang, who also spoke at the meeting) and Sweden (Rubenowitz) that reported a reduction of CVD mortality risk with increasing potassium levels in drinking water, but there were no strong associations with water hardness or calcium levels. The potassium benefits seemed to level off at about 10 mg/L in the five analytical studies that were reviewed. There are other larger CVD risk factors, however. There was a consistent finding of reduced rates of CVD associated with consumption of drinking water with increasing levels of magnesium. Even a small percentage benefit, if real, would have a very significant impact on death rates and public health.

Magnesium: Mg is one of the earth's most common element and from highly soluble salt. high concentration of Mg is undesirable in potable water as it causes scale formation and cathartic and diuretic effect. Especially when associated with Sulphate. Many earlier research worker have studied Mg in the drinking water and also reported its toxicity towards living things. The level of Mg of water sample analyzed in the range of 15.34-29.93 mg/L with grand mean value of 23.47 mg/L, which is in the safe limit recommended by WHO i.e. 36.45 mg/L. Mg mean value for Hayatabad, sadder, City, sheikh Mohammdi, Jagra and Palosi were 16.46 m^{-1}, 21.21m^{-1}, 24.33 m^{-1}, 26.34 m^{-1}, 27.28 mg/L and 25.20 mg/L respectively.

The nutritional essentiality and benefits from sufficient dietary intakes of magnesium are well established but quantitatively imprecise. Most of the epidemiology studies conducted since the mid-1950s support the hypothesis that extra magnesium in drinking water can contribute to reduced Cardiovascular Disease (CVD) and other health benefits in populations. This is the so-called 'hard water cardiovascular disease benefits hypothesis' (National Institute of Occupational Safety and Health, 1991).

Magnesium is an essential co-factor for more than 350 enzyme systems and it is involved in energy metabolism, nucleic acid synthesis, cellular balance, cardiovascular health and hormonal functions. Low magnesium intake has been associated with osteoporosis, increased calcium balance, insulin resistance, metabolic syndrome, increased oxidant stress and increased risk of cardiovascular disease (Tuthill and Calabrese, 1991).

The adult human body contains about 24 grams of magnesium, about half in bone and the remainder in soft tissue; only about 0.3% is in serum. There is no simple, rapid and accurate test to assess a person's magnesium status (Armstrong, 2002).

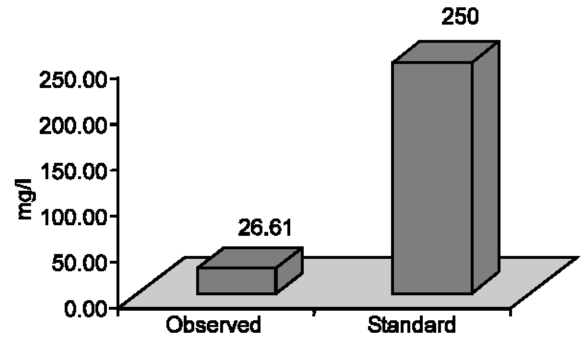

Fig. 1: Na concentration (observed vs standard)

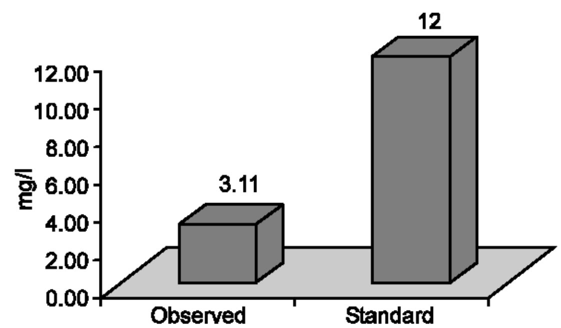

Fig. 2: K concentration (observed vs standard)

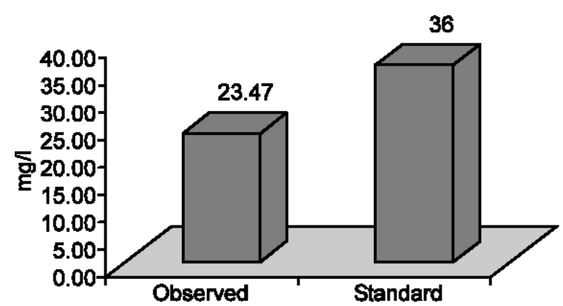

Fig. 3: Mg concentration (observed vs standard)

Calcium: Ca is present in all natural water as its level depends upon the type of rocks through which the water passes. It is usually present in the form of Carbonates, Bicarbonates, Sulphate, Chlorides and Nitrate. Ca contribute the hardness of water but also essential for human diet.

The concentration of Ca found in the water sample of Peshawar valley ranged from 12.30-87.57mg/L with grand mean of 40.96 mg/L which is in the safe limit recommended by WHO i.e. is 100 mg/L. Mean value for Hayatabad, sadder, City, sheikh Mohammdi, Jagra and Palosi were 24.74 m^{-1}, 34.36 m^{-1}, 38.05 m^{-1}, 52.04 m^{-1}, 50.35 mg/L and 46.19 mg/L respectively.

Calcium plays important roles in bone structure, muscle contraction, nerve impulses transmission, blood

Table 2: Micronutrient of water sample

Area	Ca mg/L	Zn mg/L	Cu mg/L
	Mean±SD		
Total urban (n = 45)	32.38±11.03	0.08±0.13	0.09±0.03
Hayatabad (n = 15)	24.74±6.73	0.10±0.14	0.07±0.01
Sadder (n = 15)	34.36±12.51	0.04±0.06	0.10±0.03
City (n = 15)	38.05±8.89	0.11±0.17	0.11±0.01
Total rural (n = 45)	49.53±17.57	0.10±0.14	0.14±0.01
Sheikh Mohammadi (n = 15)	52.04±18.89	0.04±0.13	0.13±0.01
Jagra (n = 15)	50.35±15.99	0.12±0.14	0.13±0.01
Palosi (n = 15)	46.19±18.38	0.14±0.15	0.14±0.01
Grand total (n = 90)	40.96±16.94	0.09±0.14	0.11±0.03

Table 2 represent the mineral content of water sample. Among the mineral content Ca, Zn and Cu were analyzed for their mineral chemical characteristics and then compared with WHO standards

clotting and cell signaling; 99% of calcium is in bone and teeth and the remainder is in soft tissue. Low intake is associated with osteoporosis, rickets and hypertension. Consumption in drinking water also reduces the risk of kidney stones, probably by complexing with oxalates in the diet that compose some types of kidney stones (Kurtz and Morris, 1993). U.S. EPA noted that the mineral content of drinking waters varies widely throughout the world as well as within countries. Some examples ranged from about 2-89 mg/L for calcium.

Above the recommended limit of WHO it may create the problem like deposition in water system and excessive scales formation.

Zinc: Zn content concentration in water sample collected from Peshawar valley varies. Zn value ranges from 0.00-0.57 mg/L. Mean value for Hayatabad, sadder, City, sheikh Mohammdi, Jagra and Palosi were 0.10, 0.04, 0.11, 0.04, 0.12 and 0.14 mg/L respectively which is below the recommended level of WHO i.e. 15 mg/L.

Zinc is an essential micronutrient of plant and animals. It plays a significant role in the enzymatic system of human body e.g. the enzyme like aldolase, alkaline phosphates, etc depend totally on zinc. It is also essential for the normal functioning of the cells including protein synthesis, carbohydrate metabolism, cell growth and cell division (ATA and TF, 1996).

The zinc deficiency results into retardation of growth, anorexia, lesions of the skin and impaired development and function of reproductive organs. On the other hand when zinc concentration is exceeded then it causes fever, depression, malaisc, cough, vomiting, salvation and headache. However its toxicity is less than that of other heavy metals like Cd, As and Sb.

Copper: Cu content contamination was not widely effected by area. Its mean content among different locations ranges from 0.01-0.15 mg/L. Mean value for Hayatabad, sadder, City, Sheikh Mohammadi, Jagra and Palosi were 0.07, 0.10, 0.11, 0.13, 0.13 and 0.14 mg/L respectively with the grand mean value 0.11 mg/L is in toxic range, as it was higher than the maximum toxic

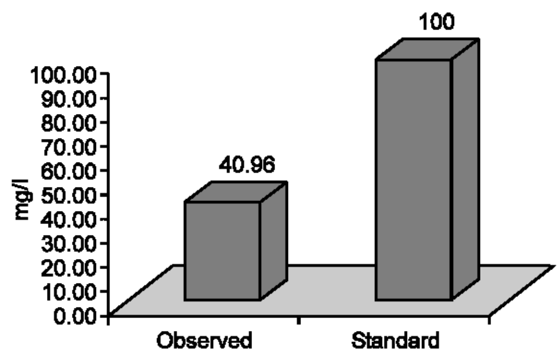

Fig. 4: Ca concentration (observed vs standard)

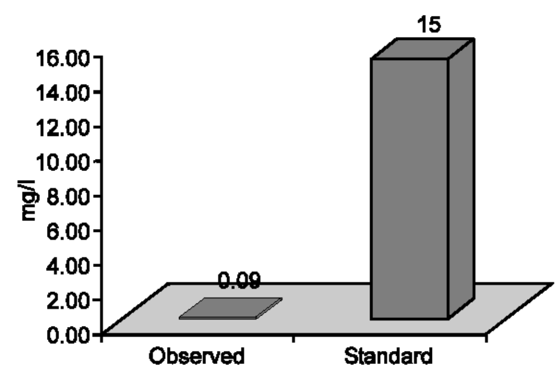

Fig. 5: Zn concentration (observed vs standard)

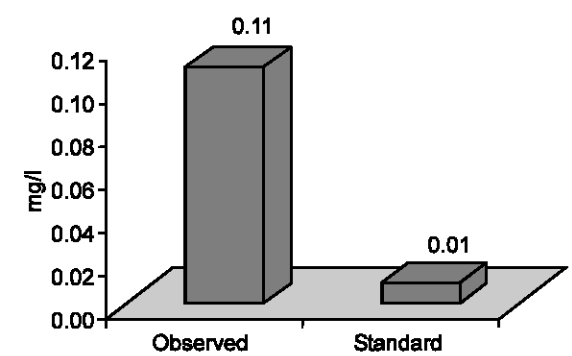

Fig. 6: Cu concentration (observed vs standard)

level (0.01 mg/L) with recommended by WHO (1999) this amount agrees with the result of Afia Zia *et al.* (2006) who reported its range from 0.011-0.0199 mg/L Cu content.

Copper concentrations in drinking-water often increase during distribution, especially in systems with an acid pH or high-carbonate waters with an alkaline pH (US EPA, 1995).

Cu rarely occurs in natural water. Most copper contamination in drinking water happens in the water delivery system, as a result of corrosion of the copper pipes or fittings. Copper level above the permissible limit can cause a bitter metallic taste in eater and result in blue green stains on plumbing fixtures. Stomach intestinal distress such as nausea, vomiting, diarrhea, stomach cramp and liver and kidney damage are the health problem associated with Cu contaminated drinking water (Zacarias, 2001).

Cu is also essential micronutrient and is required by the body in very small amount. People with Wilson's disease are more sensitive to copper deficiency, infants and children up to ten years old have a greater sensitivity to copper (Yarze, 1999).

Lead: Table 3 shows Pb concentration, which varies from location to location. This variation in Pb concentration is due to outdated piping, Pb value ranged from 0.00-0.41 mg/L with mean value of 0.15 mg/L which is above the recommended level of WHO i.e. 0.05 mg/L (WHO 1999) Mean value for Hayatabad, sadder, City, Sheikh Mohammadi, Jagra and Palosi were 0.18 m^{-1}, 0.18 m^{-1}, 0.15 m^{-1}, 0.11 m^{-1}, 0.14 mg/L and 0.15 mg/L respectively this value agree with the result of (Afia Zia *et al.*, 2006) who reported its value from 0.162-0.421 mg/L. The mean concentrations of Pb in the entire water sample were high than the recommended value because of corrosion of Pb based solder pipe joints, galvanized pipes and fittings (Ihsanullah *et al.*, 1999).

Lead is metal found in natural deposits, can't be seen, smelled, or tasted. It is found in food, paint, dust, soil, smoke and even in drinking water. In water main cause of Pb contamination is old piping and industrial discharge. Children and pregnant women are very susceptible to health risk from lead in drinking water (EPA, 2002).

Most lead contamination of drinking water occurs when soft acid water corrodes lead or galvanized pipe or corrodes solder used in pipe fittings. Lead is used in insecticide and in high-octane gasoline. But its main source of contamination is vehicle discharge and industrial effluent, which contaminate normal water bodies resulting serious ground water contamination through leaching.

Lead broadly effect human organs and systems. The most sensitive is Central Nervous System (CNS) particularly in children. Lead also damage kidney and immune system. The exposure of unborn children due to mother is also dangerous which results harmful effects include pre-mature birth, smaller babies and decreased mental ability in the infants, learning difficulties and reduce growth in young children. Lead can cause stroke, kidney disease, and cancer form a lifetime exposure at level above the MCL (Yang *et al.*, 1999).

Iron: Iron is one of the most troublesome element in water supplies. Rainwater as it infiltrates the soil and underlying geologic formation dissolve iron, causing it to seep into aquifers that serves as sources of groundwater for wells.

Table 4 show the Fe concentration in samples of drinking water of Peshawar valley. Fe concentration ranged from 0.42-0.99 mg/L with grand mean of 0.68 mg/L Fe concentration Mean value for Hayatabad, sadder, City, Sheikh Mohammadi, Jagra and Palosi were 0.50, 0.53, 0.62, 0.74, 0.79 mg/L and 0.88 mg/L respectively which is below the recommended level of WHO i.e. 0.3 mg/L.

Iron limit for drinking water are based on aesthetic parameters rather than on toxicity. Iron is mainly present in water in two forms either soluble ferrous ion or the insoluble ferric ion. Water containing ferrous is clear and colorless, when exposed to air in the pressure tank or atmosphere, the water turns cloudy and a reddish substance begins to form. This sediment is the oxidized or ferric form of iron that dissolved in water. Iron is not hazardous to health, but it is considered a secondary or aesthetics contaminant (EPA, 2002).

Iron is essential for good health, iron helps to transport oxygen in the blood, dissolve ferrous iron gives disagreeable taste. When the iron combines with tea, coffee and other beverages it produce an inky, black, appearance and a harsh unacceptable taste.

Chromium: Cr concentrations in drinking water sample were found in the range of 0.12-0.35 mg/L with grand mean 0.21 gmL^{-1}. Mean value for Hayatabad, sadder, City, Sheikh Mohammadi, Jagra and Palosi were 0.21, 0.21, 0.24, 0.20, 0.20 and 0.19 mg/L respectively which is above the WHO recommended limit i.e. 0.050 mg/L.

The higher concentration was found in City due to congested old piping, low mean concentration was found in Palosi and it was mainly that the source of drinking water are surface wells of home water supply.

The tap water contamination may be due to corrosion of Cr discharge from steel and pulp mills, erosion of natural deposits. Cr is a metal found in nature with other metal deposits. They are mainly used in metals alloys like stainless steel, protective coating on metal, magnetic tapes and pigments for paint, cement, paper, rubber, composite floor covering and materials. It's soluble from are used in wood protective (Winter, 2003).

Table 3: Heavy metals of water sample

Area	Pb mg/L	Fe mg/L	Cr mg/L	Mn mg/L
	Mean±SD			
Total urban (n = 45)	0.17±0.10	0.55±0.07	0.22±0.05	0.01±0.01
Hayatabad (n = 15)	0.18±0.12	0.50±0.06	0.21±0.05	0.01±0.01
Sadder (n = 15)	0.18±0.09	0.53±0.04	0.21±0.05	0.01±0.01
City (n = 15)	0.15±0.10	0.62±0.05	0.24±0.04	0.00±0.00
Total rural (n = 45)	0.14±0.11	2.76±13.15	0.20±0.04	0.01±0.01
Sheikh Mohammadi (n = 15)	0.11±0.10	0.74±0.09	0.20±0.04	0.01±0.02
Jagra (n = 15)	0.14±0.12	0.79±0.11	0.20±0.04	0.01±0.01
Palosi (n = 15)	0.15±0.10	0.88±0.07	0.19±0.05	0.01±0.02
Grand total (n = 90)	0.15±0.11	0.68±0.15	0.21±0.05	0.01±0.01

Table 3 represent the heavy metals analyzed in the drinking water of Peshawar valley. Among the heavy metals Pb, Fe, Cr and Mn were analyzed

Table 4: Chemical content of water sample

Area	NO_3 mg/L	SO_4 mg/L	Cl mg/L
	Mean±SD		
Total urban (n = 45)	4.25±1.10	9.50±3.48	14.96±4.58
Hayatabad (n = 15)	4±1.31	8±1.84	17±4.55
Sadder (n = 15)	4±0.97	9±2.03	13±4.11
City (n = 15)	4±1.07	12±4.65	15±4.34
Total rural (n = 45)	5.46±1.11	14.93±7.70	12.56±4.96
Sheikh Mohammadi (n = 15)	5±0.87	16±6.09	12±1.60
Jagra (n = 15)	6±1.26	17±4.89	13±6.81
Palosi (n = 15)	5±1.09	12±10.47	13±5.14
Grand total (n = 90)	5±1.26	12±6.54	14±4.90

Table 4 indicates the chemical content of drinking water sample collected from Peshawar valley. Among the chemical content NO_3, SO_4 and Cl were analyzed

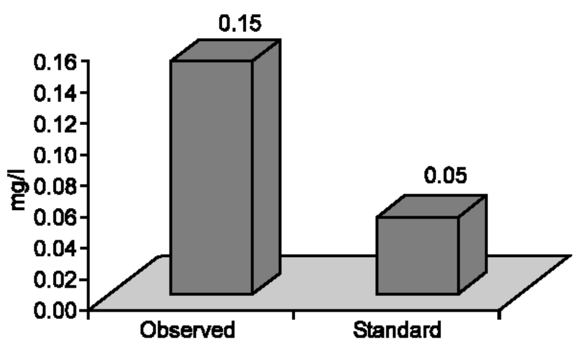

Fig. 7: Pb concentration(observed vs standard)

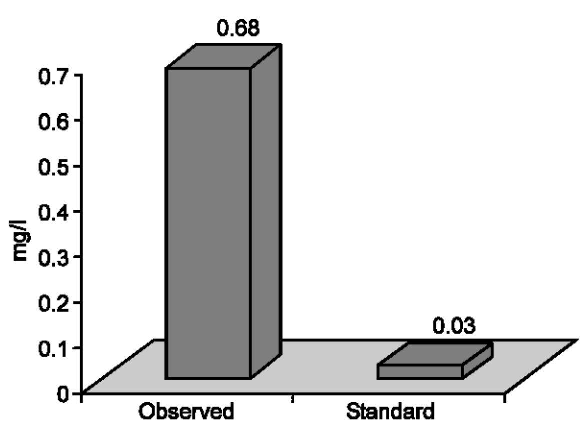

Fig. 8: Fe concentration(observed vs standard)

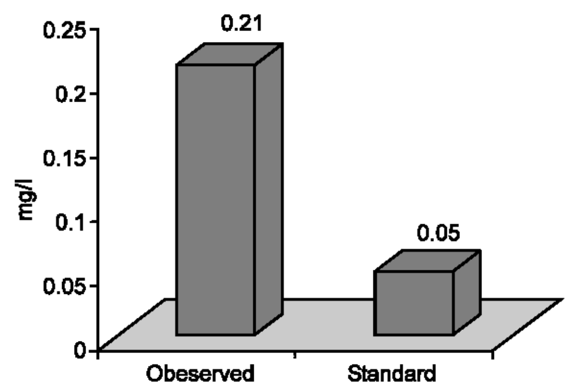

Fig. 9: Cr concentration(observed vs standard)

Ingestion of Cr in large amount can cause stomach upset and ulcer, convulsions, kidney and liver damage and even death (WHO, 1999).
The Cr harmfulness to the fetus or its ability to reproduction is unknown but experiment done on mice showed that large amount of Cr ingested had reproductive problems and offspring with birth defects. A life time exposure to Cr at level above the MCL can cause damage to liver, kidney, circulatory and nerve tissues and skin irritation.
Ingestion of 1-5 g of "chromate" (not further specified) results in severe acute effects such as gastrointestinal disorders, hemorrhagic diathesis and convulsions.

Death may occur following cardiovascular shock in some occupational studies, increased incidences of genotoxic effects such as chromosomal aberrations and sister chromatid exchanges have been found in workers exposed to chromium (VI) compounds and mortality due to lung cancer (Janus and Krajnc, 2000).

Manganese: The concentration of Mn found in the water sample of Peshawar valley ranged from 0.00-0.05 mg/L with grand mean of 0.01 mg/L which is in the safe limit recommended by WHO i.e 0.05 mg/L. Mean value for Hayatabad, sadder, City, Sheikh Mohammadi, Jagra and Palosi were 0.01, 0.01, 0.00, 0.01, 0.01 mg/L and 0.01 mg/L respectively.

The deficiency of Mn could occur in humans. The symptoms were weight loss, transient dermatitis, occasional nausea and vomiting, change in hair and beard color and slow growth of hair and beard. Studied of Mn deficiency in animals revealed the effects on reproductive capacity, pancreatic function and other aspects of carbohydrate metabolism. There is 10-20 µg of Mn in the adult human body while serum concentration reported to range from 1-200 µg/L (Henkin, 1976).

Mn toxicity has been seen in minors as a result of absorption of Mn through the respiratory tract after prolonged exposure to dust. The excess accumulates in the liver and central nervous system. Symptoms resemble those found in Parkinson's and Wilson's disease (Yarze, 1999).

Nitrate: Nitrogen is the nutrient applied in the largest quantities for lawn and garden care and crop production. In addition to fertilizer, nitrogen passes naturally to the soil from decaying plant and animals' residue. In the soil, bacteria convert various forms of nitrogen to nitrates. This is desirable as greater extent of the nitrogen used by plant is absorbed in the nitrate form. However nitrate is highly leeachable and readily moves with water through the soil profile. If there is excessive rainfall or over irrigation, nitrate will be leached below the plants root zone and eventually reach ground water. Nitrate nitrogen in ground water may result from point sources such as sewage disposal system and livestock facilities as wells as from non point sources such as fertilized cropland, parks, golf courses, lawns and gardens. Proper site selection for the location for domestic water well and proper construction can reduce potential nitrate contamination of drinking water sources (Weinberg, 2006).

The concentration of drinking water sample collected from Peshawar valley in the range of 2-8 mg/L with mean Nitrate value of 5 mg/L. Mean value of nitrate for Hayatabad, sadder, City, Sheikh Mohammadi, Jagra and Palosi were 4, 4, 4, 5, 6 and 5 mg/L respectively which is in the permissible limit recommended by WHO i.e 45 mg/L. All the water sample are below the recommended limit of WHO which is safe for health.

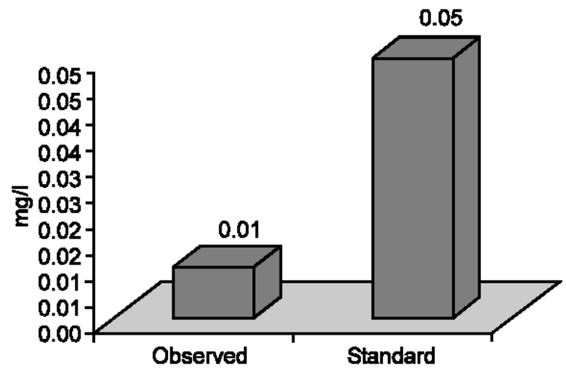

Fig. 10: Mn concentration(observed vs standard)

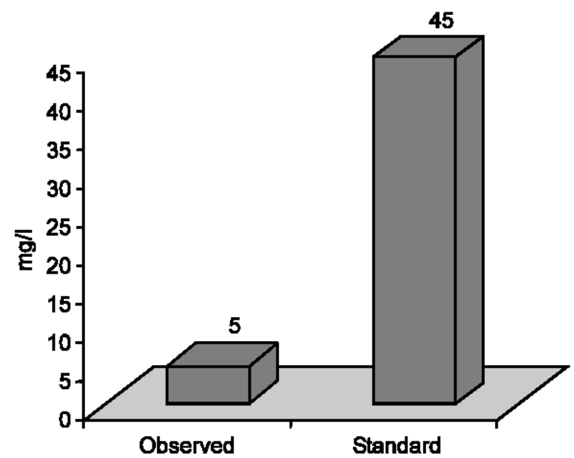

Fig. 11: Nitrate concentration (observed vs standard)

When the level of Nitrate exceeds the permissible limit then the primary health hazard from drinking water with Nitrate Nitrogen may occur when Nitrate is transformed to Nitrite in the digestive system. The Nitrite oxidizes iron in the hemoglobin of the red blood cells to form methemoglobin and causes methemoglobineria or blue baby syndrome (a situation in which blood lack the ability to carry sufficient oxygen to he individual body cells causing the veins and skin to appear blue). Most children over one year of age have the ability to rapidly convert methemoglobin back to oxy hemoglobin, hence the total amount of methemoglobin with in red blood cells remains low in spite of relatively high level of Nitrate/Nitrite uptake. However in infants under six months of age the enzyme systems for reducing methemoglobin to oxyhemoglobin are incompletely developed and methemoglobineria can occur. This also may happen in older individuals who have genetically impaired enzyme system for metabolizing methemoglobin (Yang *et al.*, 1999).

Sulphate: Sulphate is a combination of sulfur and oxygen and is a part of naturally occurring minerals in some soil and rock formation that contain groundwater. The mineral dissolved over time and is released into ground water. Sulfur reducing bacteria , which use sulfur as energy source are the primary producer of large quantities of hydrogen sulfide. These bacteria chemically change natural sulfates in water to hydrogen sulfide. Sulfur reducing bacteria live in oxygen deficient environments such as deep wells, plumbing system, and water softener and water heaters. These bacteria usually flourish on the hot water side of water distribution system. Hydrogen sulfide gas also occurs naturally in some groundwater, deposits of organic matter such as decaying plant material. It is found in deep or shallow wells and also can enter surface water through springs, although it quickly escapes to the atmosphere. Hydrogen sulfide often is present in those wells which are drilled in shale or sandstone or near coal or peat deposits or oil fields (Virkutyte and Sillanpa, 2006).

Table 4 indicted the Sulphate level of drinking water sample of Peshawar valley which is in the range of 2-36 mg/L with grand mean of 12 mg/L. Mean value of sulfate for Hayatabad, sadder, City, sheikh Mohammdi, Jagra and Palosi were 8, 9, 12, 16, 17 and 12 mg/L respectively. The permissible limit for sulfate by WHO is 250 mg/L .so all the water sample in the permissible range of WHO and hence safe for drinking purpose.

Chloride: Chloride is a major constituent of most waters. It is normally present in low concentrations in surface waters, while groundwater will contain varying amounts of chloride depending on the surrounding geology.

Chloride is widely distributed in the environment, generally as sodium chloride (NaCl), potassium chloride (KCl) and calcium chloride ($CaCl_2$). The weathering and leaching of sedimentary rocks and soils and the dissolution of salt deposits release chlorides into water.

Chloride in drinking water is generally not harmful to human beings until high concentrations are reached, although it may be harmful to some people suffering from heart or kidney disease. Restrictions on chloride concentrations in drinking water are generally based on palatability requirements rather than on health. The Guidelines for Canadian Drinking Water Quality 1989 has set the aesthetic objective for chloride in drinking water at 250 mg/L.

Chloride in drinking water may impart a salty taste at concentrations as low as 100 mg/L, however, the limit of 250 mg/L is considered the taste threshold for the average individual (Kurtz and Morris, 1993).

The concentration of chloride in drinking water sample collected from Peshawar valley in the range of 0.00-26 mg/L with grand mean of chloride value of 14 mg/L.

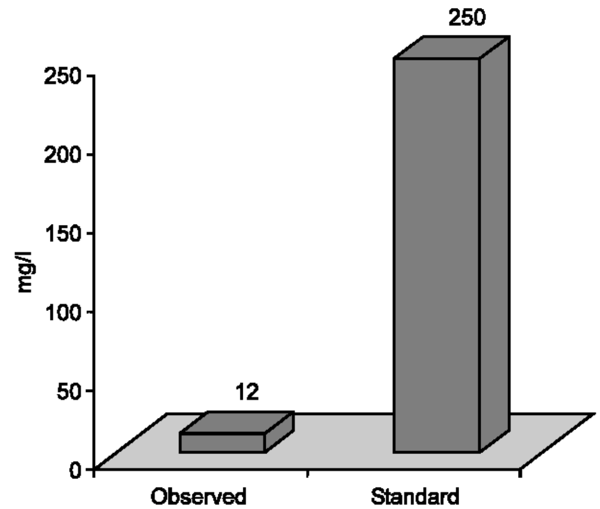

Fig. 12: Sulphate concentration (observed vs standard)

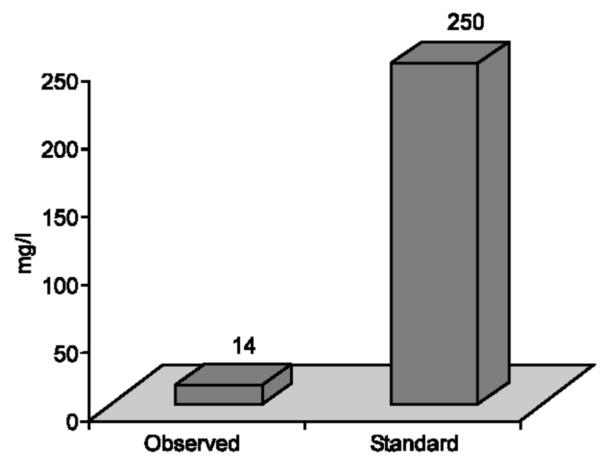

Fig. 13: Chloride concentration (observed vs standard)

Mean value of chloride for Hayatabad, sadder, City, sheikh Mohammdi, Jagra and Palosi were 17, 13 15, 12, 13 and 13 mg/L respectively. The permissible limit for chloride in drinking water is 250 mg/L. Hence all the water simples are in safe level as recommended by WHO.

Besides imparting a salty taste, chloride can affect the taste of coffee brewed in water containing a high concentration of chloride. Chlorides also appear to exert a significant effect on the rate of corrosion of steel and aluminum and can therefore affect some metals used in water handling systems.

A high level of chloride may cause gastrointestinal problems, irritation, diarrhea and dehydration (WHO, 1999).

Conclusion: The main source of contamination is the untreated sewerage water. In Peshawar City these sewage effluents are discharged directly into non-bricked and uncommented drains, sewage carrier streams and Naray Khwar running across the palosi. From there due to the seepage of polluted water, it percolates into the underground fresh water body and contaminates it. Moreover, in irrigated farming lands the chemicals, fertilizers and pesticides are used in the fields and most of these chemicals residues reached the ground water table. Smoke and wastes of vehicles are deposited on the soil surface and in rainy season it results in considerable rise in the contamination of shallow well's water. The other possible sources of heavy metals pollution, for all categories include leaching from time old water supply pipes which are rusted, Pb/Cd based solder pipes, joints and use of sub-standard chemicals for water treatments.

In Hayyatabad and Palosi the main source of heavy metal contamination may be the near by flowing Palosi drain, as it is uncemented and carries the industrial effluent discharged in to it directly from Hayyatabad industrial estate. In Peshawar the sewerage and industrial effluents are also disposed into canals or rivers, which are used for irrigation in the vicinity of Peshawar and results in the contamination of irrigation as well as drinking water. In City and Saddar the main source of water pollution is the vehicle discharged and the polluted environment and their accumulation in old piping system and solder pipes and joints. For Sheikh Mohammadi and Jagra the main source of water contamination is the leaching of chemical and synthetic fertilizer in water table as there are more agriculture land for cultivation and the improper irrigation system.

The drinking water form all the study areas is contaminated with heavy metals, so it is essential that the supply of water for human consumption should be free from unpleasant or harmful impurity and for this reason it should be subjected to various treatments to render it safe for the use of man. The study indicates from the background values that it should be monitored regularly in order to evaluate the toxic, logical significance of commonly used water for drinking.

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