INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

LEVELS OF SELECTED HEAVY METALS IN DRINKING WATER OF PESHAWAR CITY

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ABSTRACT
Twenty four drinking water samples from different locations of Peshawar city were analyzed for heavy metals concentration. The results showed that among different water samples the average content of Fe, Zn, Ni, Co, Cd, and Cr were in the range of trace to 0.052, 0.007 to 0.773, 0.097 to 0.250, 0.332 to 0.393, 0.019 to 0.087 and 0.125 to 0.430 mg l^{-1} respectively. From the data it can be concluded that the water samples from various locations were highly contaminated with heavy metals. It was also noted that most of the heavy metal values were above the permissible limits set by Codex Alimentarius Commission WHO. Therefore it is recommended that drinking water should be regularly monitored for heavy metals in order to prevent excessive buildup of these heavy metals in the human food chain.

KEYWORDS: water quality, heavy metals analysis.

INTRODUCTION
Toxic heavy metals in air, soil, and water are global problem that is a growing threat to humanity. There are hundreds of sources of heavy metal pollution, including the coal, natural gas, paper, and chlor-alkali industries (Alloway, B.J. ed**.** 1995). The known fatal effects of heavy metal toxicity include damaged or reduced mental and central nervous function and lower energy level. They also cause irregularity in blood composition, badly effect vital organs such as kidneys and liver. The long-term exposure of these metals result in physical, muscular, and neurological degenerative processes that cause Alzheimer's disease (brain disorder), Parkinson's disease (degenerative disease of the brain), muscular dystrophy (progressive skeletal muscle weakness), and multiple sclerosis (a nervous system disease that affects brain and spinal cord) (IOSHIC, 1999).Toxicity can result from any of the heavy metals but eight of them are considered by the Agency for toxic substances and disease registry in the top 20 hazardous substances list. These metals include arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury and platinum **(**ATSDR, 1992**).** Water is the most abundant substance on the earth's surface that is essential for the survival of all known forms of life. Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances, industrial cooling and transportation. More than 70% of freshwater is consumed by agriculture (Baroni *et al.,* 2007).

Drinking water is obtained from a variety of sources like wells, tube wells, rivers, lakes, reservoirs and ponds. That poses the greatest risk to human health due to contamination of these sources. Water pollutants mainly consist of heavy metals, microorganisms, fertilizers and thousands of toxic organic compounds. Heavy metals in water occur only in trace levels but are more toxic to the human body. Keeping in view the hazardous nature of heavy metals contamination in water, it was imperative to initiate this study to assess the nature of the problem and suggest ways and means to minimize the risk of toxic metals contamination of drinking water in Peshawar city of Pakistan.

MATERIAL AND METHODS
In the present study, drinking water samples of Peshawar city were evaluated for heavy metals (Fe, Zn, Co, Ni, Cr and Cd) contamination. Sampling was done in random manner from different localities of Peshawar city. The research work was carried out in Food and Environmental Protection laboratory, Food Science Division, NIFA, Peshawar and laboratory of the Department of Agricultural Chemistry, KP Agricultural University Peshawar.

Sample Collection
Water samples were collected in 1 liter capacity plastic bottles. Before sampling, the bottles were washed with detergent followed by tap water and finally several times rinsed with distilled water. The source for all water samples was tape water supplied by Municipal Corporation. The water at the sample site were allowed to flow for some time then the bottles were rinsed thrice with this water and 1 liter was taken as sample from each source of water. The samples were properly tagged. These samples were air tightened and stored in a refrigerator till the complete analyses were carried out.

Heavy Metals Analysis
Heavy metals (Fe, Zn, Ni, Cd, Co, and Cr) were determined with the help of Atomic Absorption spectrometry by using standard method of AOAC 2000. Atomic Absorption spectrometry (AAS) was one of the most commonly used instrumental techniques of analysis for the quantization of metals and metalloid in water and food samples. The Atomic Absorption Spectrophotometer Model (Perkins Elmer 2000) was used for the analysis of water samples.

The AAS method is based upon the fact that atoms in their ground state can absorb light of a particular energy (i.e. frequency). This process is the reverse of the emission of light by atoms excited by being exposed to energy (e.g. thermal energy in flame photometry). In AAS, light of a definite wavelength radiates through the atomizer system (flame or graphite tube cuvette) and is absorbed there by atoms in the ground state. The quantity of absorbed light is proportional to the concentration of non-excited atoms. It is measured as selective resonance in a detector.

Atomic absorption spectrophotometer consists of a hollow cathode lamp, a nebulizer, acetylene gas cylinder, monochromatic system, photomultiplier tube and amplifier and readout system.

During Atomic absorption spectrophotometer application, flow rate of acetylene gas was set at 2.5 L / minute and flow rate of oxidant was set at 5 L / minute. A pressure of acetylene flow was set to 80 PSI. Respective metals standards were run through the capillary pipe of nebulizer. Graphs of each standard solution were drawn by establishing a curve of absorbance against concentration. On the basis of respective standard curves, each metal was analyzed on atomic absorption for their absorbance reading. The working conditions of AAS are listed below:

Model:	Perkins-Elmer 2000
Carrier Gas:	Acetylene gas
Oxidant:	Compressed Air
Flame Temp:	2500 ^{0}C
Lamp:	Hollow Cathode Lamp (HCL)
Lamp Type:	Neon HCL
Gas flow:	2.5 L / min
Air flow:	5 L / min
Gas pressure:	80 PSI

TABLE-1 The wavelengths used for determination of various heavy metals are given below:

Metal	Wave-length (nm)
Fe	248.3
Zn	213.9
Ni	232
Cd	228.8
Co	240.7
Cr	357.9

Statistical Analysis

The data were statistically analyzed using SPSS package by applying one-way ANOVA. For checking the mean difference, T-test of this package was performed.

RESULTS AND DISCUSSION

Water contamination has increased enormously as a result of intentional and unintentional activities of human beings. Pollution of our soil, air, water and food resources has reached alarming proportions. Several reports have appeared in the press and technical literature showing the gravity of man-made environment related problems. The toxic heavy metals especially Pb and Cd affect by damaging vital body organs and related biological processes, in view of the existing grave situation in regard to environmental pollutants. It was desired essential to determine the heavy metal level of drinking water of Peshawar city.

In the present study, concentrations of toxic metals were determined in drinking water of Peshawar city area in order to evaluate its quality. The results are presented in the form of tables.

Iron

Iron is an essential element if present in permissible range, however, in case of higher concentration in water, their toxicity can cause a number of health problems in the community. The data (Table 2) indicated the concentration of Fe in water samples that range from trace to 0.052 mg l^{-1}. Highest concentration of Fe (0.052 mg l^{-1}) was observed in the sample from Tarnab while lowest concentration of Fe was found in the sample from Latifabad. Data showed significant variation among the sampling area ($P<0.05$). In a previous study on drinking water of Peshawar, Ilyaas and Sarwar (2003) reported Fe concentration of drinking water up to 0.30 mg l^{-1}. Data showed that Fe content were in the range of permissible limit 0.3 mg l^{-1} of (WHO, 2003).

Zinc

Even though zinc is an essential requirement for a healthy body, excess zinc can be harmful, and cause zinc toxicity. In nature the surface water concentration of zinc is usually below 10 µg l^{-1} and in groundwater between 10–40 µg l^{-1}. In tap water, the zinc concentration can be much higher as a result of the leaching of zinc from piping and fittings reported by Elinder (1986). The data (Table 2) showed the mean values of Zn in water samples were from 0.007 to 0.773 mg l^{-1}. The maximum level of Zn (0.773 mg l^{-1}) was detected in the sample taken from Hazarkhwani while minimum level (0.007 mg l^{-1}) was observed in the sample obtained from Chughulpura. Results showed that the area has a significant effect on the Zn concentration of water sample. Zn concentration in drinking water of Peshawar was also reported by Ilyaas and Sarwar (2003). The data indicated that Zn content of water was below the permissible limit of 3.0 mg l^{-1} reported by WHO (2003).

Nickel

Nickel is a ubiquitous metal, which finds increasingly more applications in modern technologies. Contact with nickel compounds (both soluble and insoluble) can cause a variety of adverse effects on human health. Drinking water and food are the main sources of exposure for the general population (Aleksandra and Urszula, 2008)

The data (Table 2) revealed the mean values of Ni in water samples range from 0.097 to 0.250 mg l^{-1}. The highest concentration of Ni (0.250 mg l^{-1}) was found in the sample collected from Tarnab while the lowest level of Ni (0.097 mg l^{-1}) was detected in the sample obtained from Gulbahar. The statistical analysis showed that the area has a significant effect on the Ni concentration of water sample. The nickel content of all the samples in the study were higher then the permissible limit 0.02 mg l^{-1} defined by WHO (2003).

The primary natural source of nickel in drinking water is leaching from ultramafic rocks and the soil derived from these rocks. It is found primarily combined with oxygen (oxides) or sulfide Nickel compounds are also used for nickel plating, to color ceramics, to make some batteries and as catalyst in different chemical processes. These may be the possible means for water contamination. Nickel is required to maintain health in animals. A small amount of nickel may be essential for human, although a lack of nickel has not been found to effect peoples' health (EPA, 2002).

Cobalt

Cobalt is beneficial for humans because it is a part of vitamin B_{12}, which is essential for human health. Cobalt is used to treat anemia with pregnant women, because it stimulates the production of red blood cells. However, too high concentrations of cobalt may damage human health. (Shahida *et al*. 2009)

The data (Table 2) indicated the average content of Co in water samples that were from 0.332 to 0.393 mg l^{-1}. The highest level of Co (0.393 mg l^{-1}) was observed in the sample from Gulbahar while the lowest concentration of Co (0.332 mg l^{-1}) was found in the sample collected from Tarnab. The grand mean value of Co in these samples was 0.368 mg l^{-1}. The Co concentration varies among the different locations ($P<0.05$). In similar study Zekunde and Dimins (2001) reported Co concentration of drinking water in the range from trace to 0.720 mg l^{-1}. The present data showed that the Co content of all the samples were much greater than the permissible limit of 0.05 mg l^{-1} (WHO, 2003).

Cobalt is an element that occurs naturally in the environment in air, water, soil, rocks, plants and animals. It may also enter air and water and settle on land through wind-blown dust and enter surface water through run-off when rainwater runs through soil and rock containing cobalt.Humans add cobalt by releasing small amounts into the atmosphere from coal combustion and mining, processing of cobalt-containing ores and the production and use of cobalt chemicals.Cobalt cannot be destroyed once it has entered the environment. It may react with other particles or adsorb on soil particles or water sediments (Mohapatra *et al*. 1999).

TABLE 2: Fe, Zn, Ni, Co, Cd and Cr concentration (mg l^{-1}) of drinking water in different areas of Peshawar City

S.No.	Sampling Areas	Fe	Zn	Ni	Co	Cd	Cr
		Mean values in mg l^{-1}					
1	Gulbahar	0.032 f	0.038 m	0.097 s	0.393 a	0.064 hg	0.188 r
2	Gulshan Colony	0.011 lm	0.775 b	0.127 p	0.381 d	0.019 m	0.299 h
3	General Bus Stand	0.010 m	0.202 g	0.099 r	0.365 h	0.068 f	0.211 q
4	Haji Camp	0.006 n	0.024 e	0.134 o	0.384 c	0.052 k	0.125 u
5	Latifabad No.1	-	0.034 n	0.126 p	0.379 e	0.065 g	0.266 l
6	Wazir colony	-	0.037 m	0.123 q	0.375 f	0.064 hg	0.147 t
7	Yakatoot	0.031 f	0.018 q	0.177 i	0.389 b	0.063 h	0.161 s
8	Ganj gate	0.017 j	0.041 l	0.151 n	0.376 f	0.081 b	0.213 p
9	Hashtnagri	0.012 l	0.446 e	0.133 o	0.380 ed	0.074 e	0.274 j
10	Hazarkhwani 1	0.027 g	0.182 h	0.168 l	0.379 e	0.064 hg	0.296 j
11	Hazarkhwani 2	0.019 i	0.773 c	0.159 m	0.372 g	0.048 l	0.299 h
12	Shaheedabad	0.015 k	0.006 t	0.174 j	0.389 b	0.056 j	0.229 o
13	Chughulpura	0.022 h	0.007 ts	0.174 j	0.375 f	0.087 a	0.272 k
14	Sohailabad 1	0.023 h	0.156 i	0.208 f	0.359 j	0.048 l	0.256 m
15	Sohailabad 2	0.035 e	0.315 f	0.184 h	0.384 c	0.049 l	0.361g
16	Sikandarpura	0.039 c	0.025 b	0.171 k	0.364 h	0.074 e	0.242 n
17	Rahman Baba Colony	-	0.639 d	0.197 g	0.347 m	0.060 i	0.373 f
18	Akhoonabad	0.034 e	0.133 j	0.224 d	0.356 k	0.056 j	0.386 b
19	Afridiabad	0.035 e	0.027 o	0.222 e	0.347 m	0.065 g	0.384 e
20	Nishtarabad	0.052 a	0.091 k	0.229 b	0.347 m	0.078 c	0.394 c
21	Dalazak Road	0.045 b	1.042 a	0.222 e	0.361 i	0.076 d	0.374 f
22	Afghan colony	0.039 c	0.012 r	0.227 c	0.352 l	0.053 k	0.386 d
23	Kamboh Bus stand	0.037 d	0.011 r	0.222 e	0.338 n	0.076 d	0.406 b
24	Tarnab	0.045 b	0.008 s	0.250 a	0.332 o	0.053 k	0.430 a

- Below detection limit

Cadmium

Cadmium occurs naturally in zinc, lead, copper and other ores which act as source to ground and surface waters. Cadmium can be released in drinking water from the coresion of some galinized plumbing and water main pipe material(Shahida *et al*. 2009).

The data (Table 3) presented the mean values of Cd in water samples that were in the range of 0.019 to 0.087 mg l^{-1}. The maximum level of Cd (0.087 mg l^{-1}) was detected in the sample taken from Chughulpura while the minimum level of Cd (0.019 mg l^{-1}) was found in the sample of Gulshan colony. The statistical analysis showed that the area has a significant effect on the Cd concentration of water sample ($P<0.05$). In a similar study Ihsanullah *et al.*, (1998) reported Cd concentration of drinking water in the range from 0.023 to 2.750 mg l^{-1}. The present study revealed that the overall mean value was much higher than the permissible limit of 0.003 mg l^{-1} (WHO, 2003).

The high level of Cd contamination may be due soil composition and environmental pollution in the study area. The extensive uses of Cd in protective plating for steel, pigments in plastics and glasses, electrode material in nickel-cadmium batteries and as a component of various alloys, in plastic toys and food containers enhance the risk of contamination Friberg *et al.*, (1992).

Chromium

Chromium is used in the leather tanning industry, the manufacturing of catalyst, pigment and paints, fungicides, the ceramics and glass industries. Chromium with in the recommended limit in drinking water is essential in human nutrition to maintain the normal glucose metabolism. However, if higher then the recommended level, it couses nephritis and glycosuria (Sheller and Boyle 1987). The data (Table 2) indicated the average content of Cr in water samples that range from 0.125 to 0.430 mg l^{-1}. The highest concentration of Cr (0.430 mg l^{-1}) was detected in the sample from Tarnab while the lowest concentration of Cr (0.125 mg l^{-1}) was observed in the area of Haji Camp. The Cr content of drinking water greatly varies among the different locations in the study area ($P<0.05$). In the previous study Aremu *et al*., (2002) reported Cr concentration of drinking water in the range from trace to 8.5×10^{-3} mg l^{-1}. The present work indicated that overall Cr level in the study area were above the permissible level 0.05 mg $l\text{-}^{1}$ (WHO, 2003).

The water contamination with Cr may be due to corrosion of Cr discharge from steel and pulp mills, erosion of natural deposits. Chromium is found in natural deposits containing other elements. The greatest use of Cr is in the metal alloys such as stainless steel, protective coating of metals, magnetic tapes and pigments for paints, cements, paper, rubber and other materials. Its soluble forms are used in wood preservatives Winter (2003). Ingestion of Cr in large amounts can cause stomach upsets and ulcers, convulsion, kidney and liver damage and even death (WHO, 1996).

TABLE 3: Permissible Limits for heavy metals of Drinking water set by WHO

Parameters	WHO's Permissible Limits (mg l^{-1})
Iron	0.30
Zinc	3.00
Nickel	0.02
Cadmium	0.003
Chromium	0.05
Cobalt	0.05

CONCLUSION AND RECOMMENDATIONS

It was concluded from the present study that most of the drinking water sample of the area were contaminated at alarming level. The automobile emission, industrial effluents and wastewater seepage to water table might be the possible cause.

It is suggested that drinking water should be regularly monitored for heavy metals in order to prevent excessive buildup of these heavy metals in the human food chain. Due to toxic metal contamination, the drinking water of the area should be filtered by the quality control agencies. House hold water filter should be used if possible. Water sample should be treated chemically or physically for toxic metals treatment. Heavy metal pollution is a growing environmental problem, which requires immediate attention. With current commercial remediation reagents failing to provide the needed requirements as safe and effective metal chelators, the need for new technology is critical.

REFERENCES

Alloway, B.J. ed. (1995) Heavy Metals in Soils 2nd ed. Chapters 6, 8, 9, and 11. Chapman and Hall, Glasgow, UK.

Aleksandra D, Urszula B. (2008) The impact of nickel on human health. J. Elementol. 13(4): 685-696.

AOAC. (2000) Official methods of analysis of the Association of officieal Analytical Chemists. Arlington, VA, USA. 17Th Ed. Chp. 17.

ATSDR. (1992) The Agency for Toxic Substances and Disease Registry. A Public Health Assessment Guidance Manual. U.S. Deptt. of Health and Human Services, Atlanta, Georgia.

Baroni, L., Cenci, L. and M. Berati (2007) Evaluating the environmental impact of various dietary patterns combined with different food production systems. Europ. J. of Clinical Nutr. 61: 279–286.

Elinder, C. G. (1986) Handbook on the toxicology of metals. Amsterdam, Elsevier Science Publishers, 2nd Ed: 664-679.

EPA. (2002) Environmental protection agency safe drinking water fact sheets. Islamabad, Pakistan.

Ihsanullah, A. Sattar and N. T. Khattak (1998) Heavy metal contamination of sewrege, canal and drinking water. Pak. J.of food Sci. 10(3): 37-40.

IIyas, A. and T. Sarwar (2003) Study of trace elements in drinking water in the vicinity of palosi drain,Peshawar. Pak. J. Biol. Sci. 6(1): 86-91.

IOSHIC (1999) International occupational safety and health information centre. Metals in basics of chemical safety, chapter 7, sep. geneva: international labour organization.

Mohapatra U.K., Singh B.C. (1999) Trace metal in drinking water from different sources in the old city of Cuttack. Indian Jour. of Environ. Health, 41(2) 115-120.

Roberts, J. R. (1999) Metal Toxicity in Children. Training manual on pediatric environmental health. Children's Environmental Health Network.

Shahida N. Z., Ihsnullah, M. T. Shah and Z. Iqbal (2009) Effect of time intervals on levels of selected heavy metals in surface and ground water in Peshawar basin. J. Chem. Soc. Pak., vol. 31(5)757-771.

Sheller A. M., and E. A. Boyle (1987) Geochemica et Cosmochimica Acta, 51. 3273.

WHO (1996) Health criteria and other supporting information. In: (2nd ed.),Guidelines for drinking-water quality **2**, WHO, Geneva, pp. 940–949.

WHO (2003) International year of fresh water. General Assembly Resolution A/RES/55/196. Official website: www.wateryear2003.org

Zekunde, A. and F. Dimins (2001) Contents of heavy metals in drink water from Rega; Smago metalu saturs Rigas dzeramaja udeni. Lativan University of Agriculture. 4(1): 140-144.