

CHEMICAL QUALITY ASSESSMENT OF DRINKING WATER IN DISTRICT PESHAWAR, PAKISTAN

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ABSTRACT

OBJECTIVE: This study was conducted to assess the chemical quality of drinking water in the urban areas of District Peshawar, Pakistan.

METHODS: This cross-sectional study was conducted in five urban areas of district Peshawar, (Hayatabad, University Campus, University Town, Peshawar City and Cantonment areas) from January, 2015 to June, 2015. Ethical approval was taken from the ethical committee of the Khyber Medical College (KMC), Peshawar, Pakistan. Total of 50 samples were collected from the study areas, with 10 water samples from each study areas. Water samples selected were properly sealed, labeled and were then aseptically transported to public health laboratory, KMC. All the water samples were investigated for selected water quality parameters i.e. carbon dioxide, total dissolved solids, nitrites, chlorides, chromium, lead and copper; by using atomic absorption spectrometer (AAS 700). Results were analyzed and were presented in form of table and figures.

RESULTS: Total of fifty (50) drinking water samples was selected. Study results showed that all the selected water quality parameters were beyond the WHO standard permissible limits except nitrites, chlorides and total solids concentrations which were found within permissible limits.

CONCLUSION: Quality of drinking water was not in accordance to the WHO standards and thus might pose significant health risk upon its utilization. Moreover, the concerned sectors were suggested to regularly monitor drinking water resources and to report any contaminated or associated health risk to higher authorities for appropriate remedial measures to avoid morbidity and mortality associated with drinking water.

KEY WORDS: Drinking Water (MeSH), Permissible Exposure Limits (Non-MeSH), Morbidity (MeSH), Mortality (MeSH), Peshawar (Non-MeSH).

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INTRODUCTION

The quality of drinking water is of great importance as it is considered that high concentration of heavy metals in water can be harmful to human health.¹ The chemical contamination of drinking water and water resources is a recognized problem both in developing and industrialized countries.^{2,3} The common sources of pollution in drink-

ing water can be agriculture products contamination, underground solid and liquid waste storage, land fillings, and surface impoundments. The quality of water is of vital concern for mankind as it is directly related to human health. It is well known that drinking water is the main source of water borne diseases, which wiped out many lives in the populous cities of the world. Trace metals

pollution of water is one of the rising issues for human as well as animal health as human is directly dependent on them for survival.⁴ Environmental pollution and low quality of drinking water is one of the global as well as national issues for under developed countries like Pakistan. Life is impossible without water. The entry of chemicals responsible for contamination of drinking water is through natural and manmade determinants like improper disposal of sewage and solid wastes, over application of pesticides & fertilizers, deteriorating condition of piping network and transportation vehicles.^{2,5}

According to the National Drinking Water Policy (NDWP) of 2009,⁶ Pakistan's goal is to provide universal access to drinking water in an equitable, efficient and sustainable manner by 2025. Underground water is considered comparatively safer source of water, because it is natural, purified and filtered. But nowadays, there is a serious threat to ground water due to the industrialization and other anthropogenic activities. Surface water is the source of drinking water in some parts of the world.⁷ Surface water contamination is usually of mild nature and resulting in physiological changes in the water quality. The ground water looks clean, transparent and uncontaminated, is actually more contaminated as compared to surface water pollution.⁸

There are some parameters which are essentially present in water i.e. physical, chemical and biological parameters. The amounts of these parameters which are exceeding their permissible limit are dangerous for the health of human beings. Water can be polluted by physical, chemical, or biological changes in water quality that adversely affects living

organisms or make water unsuitable for uses.⁹ Total dissolved solids in drinking water are the inorganic and organic salts of carbonates, bicarbonates, chlorides, sulfates, potassium, calcium and magnesium. Chloride is an anion found in drinking water and is generally combined with calcium, magnesium, or sodium in form of soluble salts. Chloride enters drinking water through many external resources such as rocks, agricultural, runoff, industrial waste water etc. Copper has high acute and chronic toxicity to aquatic life. Chronic toxic effects may include shortened lifespan, reproductive problems, lower fertility and changes in appearance or behavior.¹⁰ Lead accumulates in the bodies of water and soil organisms. Lead can enter drinking water through corrosion of pipes. This is most likely to happen when the water is slightly acidic. It causes several unwanted effects, such as: disruption of the biosynthesis of hemoglobin and anemia, a rise in blood pressure, kidney damage, miscarriages and subtle abortions.¹¹ Chromium enters the air, water and soil through natural processes and human activities. The main human activities that increase the concentrations of chromium are steel, leather tanning, chromium plating, welding and chrome pigment production.¹²

Water quality is the total chemical, physio-biological and radiological characteristics of water; is important for the survival of living species.^{13,14} Globally, humans have inadequate access to potable water and use sources contaminated with pathogens or unacceptable levels of toxins or suspended solids. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack accesses to adequate sanitation.¹⁵ However, researchers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability.¹⁶ A report by Voice of America suggests that by 2030, in some developing regions of

the world, water demand will exceed supply by 40%.¹⁷ This natural resource is becoming scarcer in certain places, and its availability is a major social and economic concern. Most countries accepted the goal of halving the number of people worldwide, by 2015, who do not have access to safe water and sanitation during the 2003 G8 Evian summit.¹⁸

Pakistan is now being considered among Water Stress Countries as the situation is becoming worse day by day, mainly due to an increase in population, inefficient irrigation, ill planning of water resource management, corruption and unequal water rights.¹⁹ More than 70% of the total population in Pakistan does not have access to safe drinking water and more than 70,000 children die every year due to diarrhea and other diseases related to unsafe water and poor sanitation facilities according to a report published by UNICEF.²⁰ In the developing world, 90% of all waste water still goes untreated into local rivers and streams. Approximately, 50 countries, roughly one third of the world's population, suffer from water stress and shortage. Moreover, changes in the water extraction methods affect surface freshwater bodies and also degrades the underground water resources, by interfering in the natural water cycle process.²¹ Drinking water supply and sanitation in Pakistan is characterized by many challenges. Despite high population growth the country has increased the share of the population with access to an improved water source from 85% in 1990 to 92% in 2010, and improved sanitation increased from 27% to 48%.²²

Keeping in view the above facts, being a developing country with high prevalence of contamination and pollution of the water resources; it is important to assess the quality of drinking water. So this cross-sectional study was conducted to assess various selected chemical quality parameters of drinking water; and to compare with recommended permissible WHO standards of drinking water

among urban areas of District Peshawar, Khyber Pakhtunkhwa, Pakistan, to avoid morbidity and mortality associated with consumption of contaminated drinking water.

METHODS

This cross-sectional study was conducted in selected five urban areas of district Peshawar, i.e. Hayatabad, University Campus, University Town, Peshawar City and Cantonment areas; after taking approval from the ethical committee of the Khyber Medical College Peshawar. This study was conducted for duration of six (6) months i.e. from January, 2015 to June, 2015. Total of 50 samples were collected from the study areas, with 10 water samples from each study areas. A multistage probability sampling technique was used in which initially simple random sampling was conducted to identify sectors, mohallahs and streets etc, and in the final stage, drinking water samples were selected among those units which were identified in the first stage, on the basis of simple random technique. The inclusion criteria was the drinking water samples from the study areas and the exclusion criteria was that the samples will not include underground and mineral water samples.

Water Sampling & Analysis

To conduct drinking water chemical quality assessment, representative water samples from all the selected five study areas were collected through multistage probability sampling. Before collecting the water samples the polyethylene bottles were washed with double deionized water. After labeling and sealing; each representative sample was stored in acidified bottles with 5% HNO₃ for selected elemental analysis of chloride, nitrates, carbon dioxide, total dissolved solids, chromium, copper and lead. The water samples were aseptically transported to the Public Health Laboratory, Department Of Community Medicine, Khyber Medical College Peshawar; for analysis on Atomic Absorption Spectroscopy (Model

AAS -700). The data was analyzed by Microsoft office 2010 and SPSS Version 16.0. The results were finally presented in forms of tables and graphs.

RESULTS

The main focus of this study was to assess the chemical quality assessment of drinking water parameters and to compare it against the standards set by WHO. The mean concentrations of selected parameters of total dissolved salts (TDS), Cu, Pb, Cr, Cl, Nitrites and Carbon dioxide were shown along with WHO Maximum Permissible Exposure Limits in drinking water (n= 50) from study areas of District Peshawar, Pakistan in Table I.

The main result findings were: mean carbon dioxide concentration was more than two times the permissible W.H.O standards; the presence of Nitrates in the Peshawar City and Cantonment areas made them unsuitable for potable use; mean Lead values also greatly exceeded the WHO limits and the TDS values showed variations both below and above the WHO standards with the highest concentration observed in Peshawar City. Copper concentrations were within limits except for Peshawar Cantonment

which was four times higher than the safe limit. Most notable of all is the concentration of Chromium which was on average thirty times higher than the safe limit. The minimum, maximum and mean concentrations of all the selected water quality parameters in drinking water samples (n=50) from urban areas of District Peshawar, Pakistan were shown in Figures 1 to 7.

DISCUSSION

Our study results revealed total dissolved solids mean concentration of 458.6 (± 62.158) mg per liters which was according to WHO limits (500 mg per liter). Out of all five study areas, three had TDS within while the remaining two had beyond the WHO standards. Moreover, in a previous study conducted in Peshawar showed TDS concentrations approximately 530 mg per liter²³ as was shown in Figure 1.

Drinking water having excess of copper results in gastrointestinal distress and long term exposure causes liver and kidney damage. WHO levels for Copper in drinking water is 0.05 mg per liter. Our study results showed that Cu mean concentration was 0.065 (± 0.081) mg per liter which was near to WHO limits (0.1

mg per liter). Copper concentrations in four study areas were within the allowed limit while the area Peshawar Cantonment had 0.2094 (± 0.45) mg/l which results in overall mean concentration of 0.065 (± 0.081) mg/l. Moreover, our results of Cu were above the findings of a study conducted in Turkey that revealed 1.16 micrograms per liter²⁴ as was shown in Figure 2.

Lead in drinking water can cause adverse health effects in babies and children; exposure to lead in drinking water can result in delays in physical and mental development, along with slight deficits in attention span and learning abilities. In adults, it can cause increased blood pressure. Adults who drink this water over many years could develop kidney problems or high blood pressure. Our study results showed mean lead concentrations was 0.52 (± 0.191) mg per liter which was highly above the WHO limits (0.1 mg per liter). Studies carried out in Turkey showed that lead levels were within the WHO limits²⁴ as was shown in Figure 3. Chromium has a relatively low toxicity and would be a concern in drinking water only at very high levels of contamination. High levels of chromium in drinking water can

TABLE I: MEAN CONCENTRATIONS (± STANDARD DEVIATION) OF SELECTED PARAMETERS & WHO MAXIMUM PERMISSIBLE EXPOSURE LIMITS IN DRINKING WATER (N=25) FROM STUDY AREAS OF DISTRICT PESHAWAR PAKISTAN

Parameters → Areas ↓	Carbon dioxide (Atoms/mole)	Nitrites (mg/l)	Chlorides (mg/l)	Chromium (mg/l)	Lead (mg/l)	Copper (mg/l)	Total Salts (mg/l)
Hayatabad	50.6 (±2.177)	0.7 (±0.258)	46.8 (±1.69)	1.5094 (±0.639)	0.689 (±0.325)	0.0148 (±0.0044)	430.8 (±1.605)
Peshawar City	98.4 (±3.477)	1.2 (±0.832)	85 (±3.708)	1.658 (±0.605)	0.7238 (±0.333)	0.0214 (±0.0154)	523.4 (±3.854)
Peshawar Cantonment	82.6 (±2.533)	1.5 (±1.198)	66.8 (±1.411)	1.837 (±0.153)	0.4368 (±0.35)	0.2094 (±0.45)	447.2 (±1.864)
University Campus	63.2 (±3.098)	0.2 (±0.235)	56.4 (±1.240)	1.6782 (±0.709)	0.4934 (±0.465)	0.0366 (±0.027)	516.6 (±2.075)
University Town	59.4 (±1.414)	0.8 (±0.563)	58 (±2.119)	1.4468 (±0.825)	0.2588 (±0.345)	0.0414 (±0.021)	375 (±1.605)
Sample Means	70.84 (±19.343)	0.88 (±0.496)	62.6 (±14.393)	1.626 (±0.153)	0.52 (±0.191)	0.065 (±0.081)	458.6 (±62.158)
WHO Standards (MPELs)	30	1	250	0.05	0.1	0.05	500

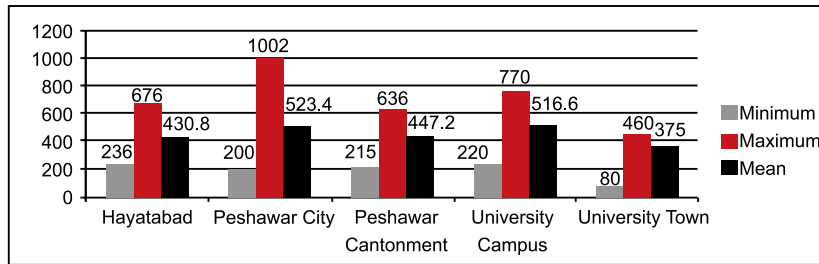


Figure 1: Concentrations of Total dissolved salts (mg/ l) in drinking water samples (n=50) from urban areas of District Peshawar Pakistan

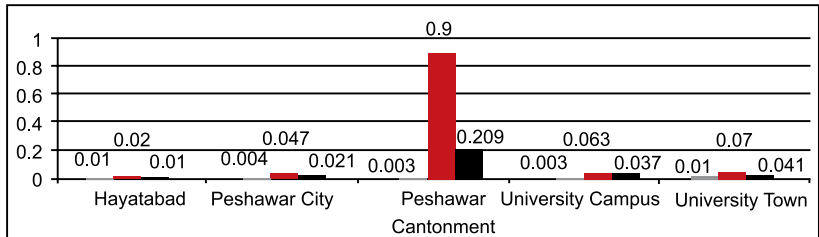


Figure 2: Concentrations of Copper (mg/ l) in drinking water samples (n=50) from urban areas of District Peshawar Pakistan

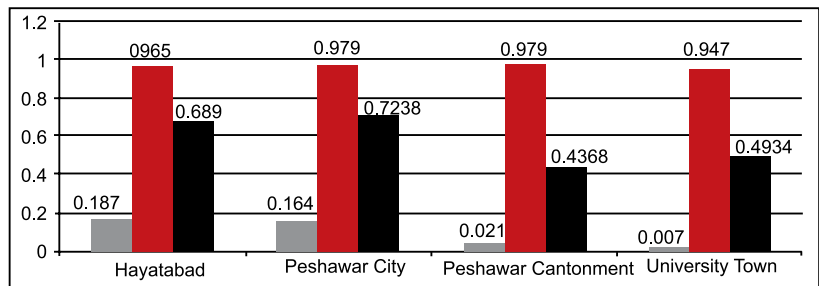


Figure 3: Concentrations of Lead (mg/ l) in drinking water samples (n=50) from urban areas of District Peshawar Pakistan

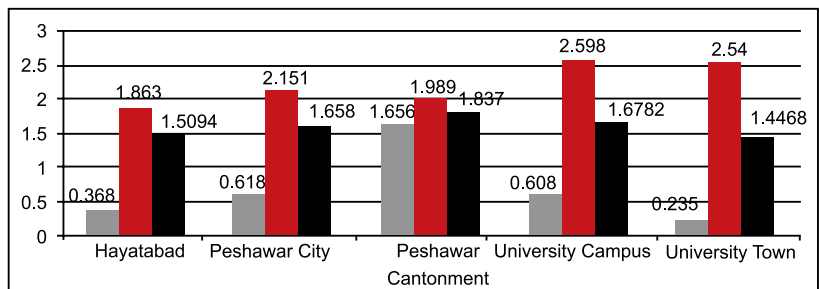


Figure 4: Concentrations of Chromium (mg/ l) in drinking water samples (n=50) from urban areas of District Peshawar Pakistan

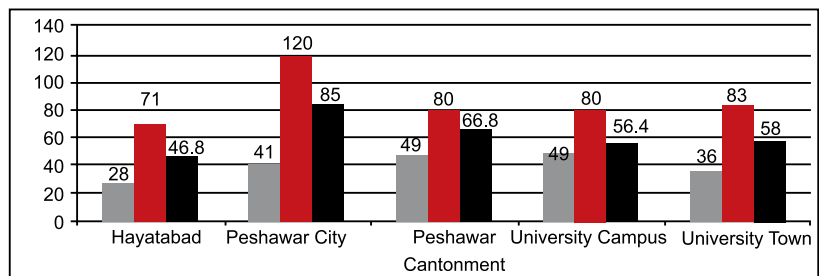


Figure 5: Concentrations of Chloride (mg/ l) in drinking water samples (n=50) from urban areas of District Peshawar Pakistan

cause allergic dermatitis. Chromium is likely to be carcinogenic to humans when ingested. Our results showed mean concentration of Cr as 1.626 (\pm 0.153) mg/l, which was far beyond the permissible WHO standards (0.05 mg/l). This is an extremely high value which indicates that the chromium content of our water falls in the highly toxic range, as was shown in Figure 4. Chlorine is relatively harmless as compared to other chemicals, because it reacts quickly with other substances present in water or dissipates as gas into the atmosphere. Chlorine is usually added to the water as a disinfectant. Chlorine can cause irritation to eyes nasal passages and lungs. In our study the mean concentration of chlorine 62.6 (\pm 14.393) mg per liter; which is within WHO standards as shown in Table I; whereas in studies conducted in Gujarat showed that chlorine concentrations were beyond WHO limits of 150mg/l.²⁵ In a similar study conducted in Lahore, revealed that chloride content was 95 mg per liter which was still lower than the WHO standards but higher than our results^{26,27} as was shown in Figure 5.

High levels of nitrites can cause multiple abnormalities. Nitrites react directly with hemoglobin in human blood to produce met-hemoglobin, which destroys the ability of blood cells to transport oxygen. This condition is especially serious in babies under three months of age as it causes a condition known as met-hemoglobinemia or “blue baby” disease. Our study results showed that nitrite concentrations were within the WHO limits; less than 1 mg/l. Moreover, in studies conducted in Mardan²⁸ and Lahore,²⁶ revealed that nitrite levels were according to WHO water quality standards. Moreover, the groundwater samples taken from Jhelum, Gujarat and Sargodha districts by the United Nations Children’s Fund observed high nitrite levels due to heavy use of fertilizers in nearby of Southern Punjab.²⁹ In a study conducted in Charsadda,³⁰ the concentrations of nitrate ranges from

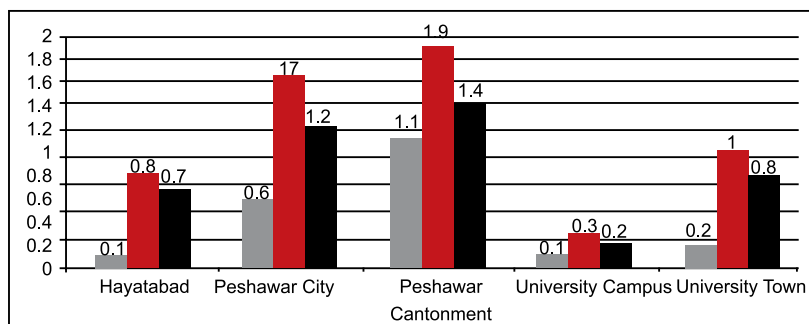


Figure 6: Concentrations of Nitrites (mg/l) in drinking water samples (n=50) from urban areas of District Peshawar Pakistan

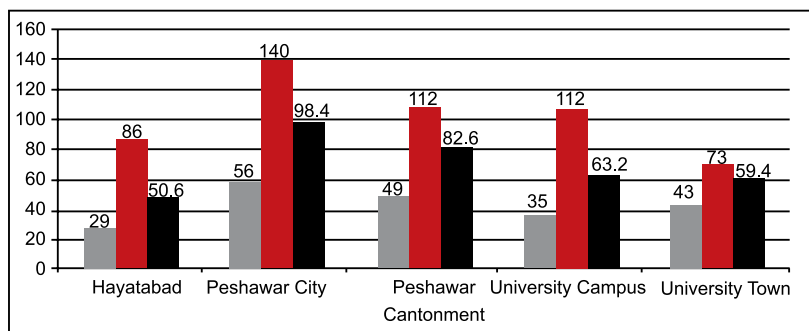


Figure 7: Concentrations of Carbon dioxide (atoms/mole) in drinking water samples (n=50) from urban areas of District Peshawar Pakistan

10.3 to 14.84 mg/l in 13 sites and were also beyond the permissible limits set by US EPA. According to Pak EPA (2008), lead in drinking water samples ranged from 1.59 to 372.2 mg/l, as was shown in figure 6. Carbon dioxide concentration determines the level of acidity of potable water. Greater the concentration of carbon dioxide, lower the PH and more acidic is the water. Consumption of acidic water can cause skin and eye irritations and gastrointestinal upsets. Our study results found that carbon dioxide concentrations had mean 70.84 (\pm 19.343) atoms per mole which was beyond WHO limits of 30 atoms per mole.³⁰ In a study conducted in Lahore found that carbon dioxide was normal²⁶ and thus our study findings revealed that it was harmful to health, as was shown in Figure 7.

CONCLUSION

From our study results, it was concluded that chemical quality of drinking water samples from the selected study areas was not in accordance to the WHO

standards and thus was unfit for drinking and utilization purposes. Moreover, the quality of Hayatabad drinking water was according to the WHO acceptable standards while the remaining areas revealed higher concentrations which are beyond the WHO maximum permissible limits; while the results of Peshawar City showed the highest variation as compared to other areas. Hayatabad had an efficiently planned water distribution system as opposed to other selected study areas of Peshawar. Therefore, appropriate measures should be taken at all levels to prevent the contamination of drinking water along with monitoring of water quality parameter standards, by the higher concerned authorities. Moreover, there is need of public education and mass awareness to avoid the contamination of drinking water resources.

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CONFLICT OF INTEREST

Authors declared no conflict of interest

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AUTHORS' CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

BI: Conception and design; drafting the manuscript; Critical revision, Supervision, final approval of the version to be published

NB, MI: Analysis and interpretation of data, drafting the manuscript, final approval of the version to be published

SAK, SS, TA: Acquisition of data, drafting the manuscript, final approval of the version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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