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HEAVY METAL ANALYSIS FROM SPRING WATERS OF POONCH DIVISION OF AZAD JAMMUA & KASHMIR

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Abstract

The present study was designed to analyze the water of springs for sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni) and copper (Cu) in four towns of central Azad Jammu and Kashmir. Total dissolved solids (TDS), pH and electric conductivity (EC) were also determined. A total of 110 samples were collected for this purpose. Quantities of all the metals were measured using flame and furnace atomic absorption spectrometer. Mean quantities of pH, TDS, and EC were found to be 8.15, 82.36 ppt and 93.35 µS/cm. The mean concentrations of Na, K, Ca and Mg were found to be 8.33, 1.08, 13.83 and 9.72 mg/L respectively. Cd was detected from 75 (68%), Pb from 70 (64%), Ni from 24 (22%), Cu from 84 (76%) and Cr from 83 (75%) samples. Mean concentrations of Cd, Pb, Ni, Cu and Cr were found to be 4.33, 2.77, 0.56, 0.39 and 0.43 µg/L respectively. The quantities of all physical parameters and metals were found within the safe limit of drinking water except for three samples of Pb and 40 samples of Cd which had slightly higher concentrations than the safe limit of drinking water.

Key Words: Spring Water; Azad Jammu and Kashmir; Heavy Metals; Atomic Absorption Spectrometer

抽象的

本研究旨在分析泉水中的钠 (Na)、钾 (K)、钙 (Ca)、镁 (Mg)、铅 (Pb)、镉 (Cd)、铬 (Cr)、镍 (Ni) 和铜 (Cu) 位于阿扎德查谟和克什米尔中部的四个城镇。还测定了总溶解固体 (TDS)、pH 值和电导率 (EC)。为此目的，共收集了 110 个样本。使用火焰和炉原子吸收光谱仪测量所有金属的数量。发现 pH、TDS 和 EC 的平均量为 8.15、82.36 ppt 和 93.35 µS/cm。 Na、K 、Ca 和 Mg 的平均浓度分别为 8.33、1.08、13.83 和 9.72 mg/L。从 75 (68%) 中检测到 Cd，从 70 (64%) 中检测到 Pb，从 24 (22%) 中检测到 Ni，从 84 (76%) 中检测到 Cu，从 83 (75%) 样本中检测到 Cr。 Cd、Pb、Ni、Cu 和 Cr 的平均浓度分别为 4.33、2.77、0.56、0.39 和 0.43

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μg/L。除铅3个样品和镉40个样品的浓度略高于饮用水安全限值外，所有物理参数和金属的含量均在饮用水安全限度内。

关键词：泉水；阿扎德查谟和克什米尔；重金属;原子吸收光谱仪

Introduction

In Azad Jammu and Kashmir, the major and most common source of water for drinking and domestic purposes is spring water. Springs are subversive water that flows out of the earth naturally without the routine practice of bores, wells or pumps. Impurities from the soil surface may easily reach the shallow sources, which leads to the greater risk of contamination in spring water as compared to other water sources. So the spring water should be investigated for heavy metals, microorganisms and other environmental pollutants which are responsible for contamination of this water source [1].

Animals and plants totally depend on the water for their survival, but growing human population, use of fertilizers in the agriculture and synthetic activities affect water quality. Spring water is contaminated with both natural and synthetic sources. Main sources of water pollution are impurities, microorganisms and chemicals. Water contamination due to heavy metals is a universal problem [2]. Heavy metals leach into groundwater and harm water consumers. Spring water contaminated with heavy metals such as lead, mercury, arsenic and cadmium are poisonous to human health. In human, high ingestion of soluble cadmium salts cause acute gastroenteritis. Long term exposure to cadmium is responsible for kidneys and liver disorders. Accumulation of copper in liver, brain and eyes also cause Wilson disease. Some heavy metals, if present in drinking water, have lethal effects including damage to central nervous system, irregularity in blood composition and damage to the vital organs [3]. People that are exposed to heavy metals for longer duration may suffer with Alzheimer's disease, Parkinson's disease and multiple sclerosis. Other heavy metals like copper, zinc and chromium are required in body in minor amounts but lethal in large concentrations. Chromium enhances the insulin receptor activity on muscle cells[4].

Calcium and magnesium are both precondition elements. Calcium plays vital role in neuromuscular excitability and blood coagulation while Magnesium plays an important role as cofactor and activator of more than 300 enzymatic reactions. Magnesium also has a role in transport of some other elements like sodium, potassium, and calcium via membranes. Spring water having low magnesium concentration is a possible cause of cardiovascular diseases and high peril of fracture in children, neurodegenerative disease, pre mature birth and some malignancy [5].

It is therefore necessary that the quality of drinking water should be checked at regular intervals. As there is no study on investigation of metals in the central part of Azad Jammu and Kashmir, the present study was designed to investigate the physical (pH, total dissolved solids and Electric Conductivity) and the chemical parameters (Ca, Mg, Na, K, Cd, Cu, Ni, Pb and Cr) of the spring water in the area.

MATERIALS AND METHODS

Study Area and Water Sampling

The study area was divided into four major towns and their associated areas which were Hajira, Rawalakot, Bagh, and Palandari. About 110 sites were selected for spring water sample from all these areas. The sampling sites were selected on the base of population density and consumption of the

spring water locally. A total of 34 samples were collected from Hajira, 33 from Rawalakot, 25 from Bagh and 18 from Palandari region. Approximately 300 ml of the water was taken from each of the selected spring in a sterile plastic bottle. The samples were labeled accordingly with representative date, time and the specific location. The bottles were immediately covered tightly and transported to the laboratory where they were stored at 4oC until subjected for further analysis.

Physical and Chemical Analysis

Physical parameter like pH, electrical conductivity and total dissolved solids were studied for all the samples. Physical measurements were carried out in three times for each sample and the average value was calculated and recorded. The average values were compared with the standard values. The average values of different parameter were also compared among the samples of four regions. The measurement of pH was performed using portable pH meter (Mettler-Toledo 8603, GmbH, Schwerzenbach, Switzerland). Electric conductivity was measured using DDS-12DW Microprocessor Conductivity Meter. EcoSense EC300A potable meter was used to measure the total dissolved solids in the samples.

Concentration of calcium, magnesium, sodium and potassium was determined with the help of flame method in atomic absorption spectrometer (Perkin Elmer Aanalyst 700, USA). Determination of cadmium, copper, chromium, nickel and lead was carried out using graphite furnace atomic absorption spectrometer. To obtain calibration curves for metal determination, standard stock solutions of metals were prepared by dissolving the standard solution of that particular metal in distilled water.

Statistical Analysis

The quantitative data was analyzed by one way analysis of variance with LSD, Tuukey's HSD and Duncan Multiple Range test (DMRT), while the qualitative data was analyzed by Pearson's Chi square test. The quantitative values of physical parameters were compared among each other and among all the four regions by one way analysis of variance (ANOVA) with DMRT. Similarly, the quantities of calcium, magnesium, sodium and potassium were compared among each other and among all the regions by one way ANOVA and DMRT. Percentage detection of cadmium, chromium, copper, lead and nickel were compared among each other and among different regions by Chi-Square test, while quantities of these metals were compared among each other and among all the regions by one way ANOVA and DMRT. All the analyses were carried out in statistical package for social sciences (SPSS) version16.0.

RESULTS AND DISCUSSION

Physical Parameters

In physical parameters, total dissolved solids (TDS), pH and electrical conductivity (EC) were analyzed. Mean TDS quantity was found to be 82.36 ± 29.98 mg/L, ranging from 36 to 187 mg/L (Table 1). The highest TDS values were recorded in the samples of Palandari region with mean value of 103.79 ± 43.22 ppt. It was significantly higher than the TDS values of the samples of Bagh region ($p=0.004$) and Rawalakot region (0.009), but not different from the samples of Hajira region (Table

1). The amounts of TDS less than 300 mg/L is considered as quality of excellent water, and the acceptable range of TDS in drinking water is 1000 mg/L (WHO, 2004). The TDS concentration in present study was within the safe limit of WHO. The range of TDS in current study is relatively lower than all the previously studied sites of tehsil Jamrud and Landikotal, Khyber Agency, Pakistan [6].

Mean pH value was found to be 8.15 ± 0.20, ranging from 7.29 to 8.54 (Table 1). Maximum pH values were found in the samples of Bagh with the mean of 8.20 ± 0.09 and the minimum values were recorded in the samples of Palandari with the average pH of 8.1 ± 0.21. Similarly the pH values of Hajira and Rawalakot were 8.15 ± 0.25 and 8.16 ± 0.20 respectively. There was no significant difference of pH among the samples of all the regions. According to WHO, the pH of the drinking water should be in the range of 6.5-8.5 (Table 1). The results of our study show that the spring waters of Hajira, Rawalakot, Bagh and Palandari are in safe pH limit for drinking purpose except for one sample having pH value of 8.54. At Kohat, Khyber Pakhtunkhwa, it was reported that pH of water in the range of 7.9 to 8.54 which is quite similar to our study and lies within the WHO recommended range of safe drinking water [6].

Mean EC value was found to be 93.35 ± 32.28 µS/cm, with a range of 12 to 207.7 µS/cm (Table 1). Mean EC values of Hajira, Rawalakot, Bagh and Palandari was 94.58 ± 36.02, 86.54 ± 18.75, 83.56 ± 20.28 and 117.09 ± 45.74 respectively. EC of the samples of Palandari was significantly higher than the samples of Rawalakot (p=0.005) and the samples of Bagh (p=0.003) but not higher than Hajira region. However the EC values were statistically same in the samples of all regions (Table 1). The water having EC values less than 500 µS/cm is considered as safe and good for drinking purpose (WHO, 2004). Our study indicates that the spring water of Hajira, Rawalakot, Bagh and Palandari is good water for drinking and has the EC in safe limit. The EC of springs of the Yarmouk Basin, North Jordan, which was found in the range of 300 to 1199 µS/cm with the average of 516.1 µS/cm which is higher than the safe EC limit of water as well as the EC of current study [7]. In our study, the EC values of Palandari region were higher than other regions probably due to higher amount of TDS in the water of the region.

Chemical Parameters

Average concentrations of sodium, potassium, calcium and magnesium were found to be 8.33 ± 7.57 mg/L, 1.08 ± 0.65 mg/L, 13.83 ± 7.27 mg/L and 9.72 ± 3.17 mg/L respectively (Table 2). The range of Sodium concentration was found to be 0.11 to 64 mg/L, the potassium was found in the range of 0.15 to 3.83 mg/L, while the concentration of calcium and magnesium was measured in the range of 3.85 to 50.83 mg/L and 1.29 to 17.18 mg/L respectively (Table 2).

There was a significant difference of concentrations (p=0.000) among the concentrations of sodium, potassium, calcium and magnesium metals. Concentration of sodium was significantly higher than potassium (p=0.000) and lower than calcium (p=0.000), while it was not different statistically from magnesium (Table 2). Potassium was significantly lower than sodium (p=0.000), calcium (p=0.000) and magnesium (p=0.000). Calcium was significantly higher than potassium (p=0.000), sodium (p=0.000) and magnesium (p=0.000). Magnesium was significantly lower (p=0.000) than calcium and significantly higher (p=0.000) than sodium while it was statistically equal to potassium (Table 2).

Highest concentration of sodium was present in the samples of Palandari with mean of 12.78 ± 13.44 mg/L and then the samples of Hajira having mean value of 7.80 ± 6.50 mg/L. The lowest quantity was recorded in the samples of Bagh region with mean value of 5.21 ± 2.11 mg/L. Sodium concentration in the samples of Palandari was significantly higher than the samples of Bagh region (p=0.006) while there was no significant difference among other regions (Table 2). Permissible limit of sodium in drinking water is 200 mg/L. In our study, the average sodium concentration was found to be 8.33 ± 7.57 mg/L ranging from 0.11 to 64 mg/L which is within the WHO recommended limit. The concentration of sodium in our study was also lower than the sodium detected by , who reported the sodium concentration in the spring water of Kohat, Khyber Pakhtunkhwa in the range of 165-300 mg/L which exceeds the WHO limits in some of their samples [6].

Decreasing order of potassium concentration among the regions was: Hajira > Rawalakot > Palandari > Bagh with the mean concentrations of 1.22 ± 0.67 mg/L, 1.12 ± 0.80 mg/L, 1.03 ± 0.50 mg/L and 0.87 ± 0.39 mg/L respectively (Table 2). However, there was no significant difference of potassium concentration among these regions. Permissible limit of potassium in drinking water is 12 mg/L [7]. The average of potassium in our study is well in the safe limit. Potassium concentration in present study is also lower than the potassium concentration detected in a previous study, who reported the potassium concentration in the water of District Kohat, with range of 6.2-18.9 mg/L. This range also exceeds the safe limit for potassium [6].

The decreasing order of calcium concentration was: Palandari > Hajira > Rawalakot > Bagh with the average calcium concentrations of 17.67 mg/L, 13.55 mg/L, 12.81 mg/L and 12.80 mg/L respectively (Table 2). However, there was no significant difference of calcium among the samples of all the regions. Permissible limit of calcium in drinking water is 75 mg/L (WHO, 2004). The average concentration of calcium in our study falls in safe limit of drinking water is far lower than the calcium detected, calcium in the spring water of Sindh, Pakistan having average of 126 mg/L [8].

The decreasing order of magnesium concentration in regions was: Hajira > Palandari > Rawalakot > Bagh with the means of 10.70 ± 3.63 mg/L, 10.27 ± 2.30 mg/L, 9.57 ± 3.17 mg/L and 8.17 ± 2.51 mg/L respectively (Table 2). The magnesium was significantly higher in the samples of Hajira as compared to the samples (p=0.01) of Bagh. In all the samples of other regions, concentration of magnesium was statistically equal (Table 2). Permissible limit of magnesium in drinking water is 150 mg/L [9]. In our study, the magnesium concentration was well inside the permissible limit. Similar results were reported by [10], who determined the mean concentration of magnesium as 10.3 mg/L in spring water of Hazara region.

Heavy Metals

Cadmium was detected from 68 % (75) of the total 110 samples. In 26.33 % of the samples, cadmium concentration was in the range of 0 to 1 µg/L, in 19.33 % of the samples, it was in the range of 2 to 3 µg/L and in the remaining 54.33 % of the samples, it was in the range of 4 to 17 µg/L. Chromium was detected from 75 % (83) of the total samples and its concentration was in the range of 0.001 to 2.09 µg/L (Table 3). Out of 83 samples (74.4%) in which chromium was detected, only 3 samples (3.61 %) had a concentration of higher than 1 µg/L while all other samples had a concentration of less than 1

µg/L. Copper was detected from 76 % (84) of the samples and its concentration was in the range of 0.005 to 1.78 µg/L (Table 3). Only one sample had a concentration of more than 1 µg/L while remaining 83 were below 1 µg/L. Lead was detected from 64 % (70) of the samples of spring water with the concentration of 0.004 to 19.39 µg/L. Out of 70 samples, 48 (68.57 %) had a concentration of 0.004 to 1 µg/L while remaining 22 samples had the concentration ranging from 2 to 19 µg/L. Nickel was detected from only 24 out of 110 samples (22 %) and its concentration was in the range of 0.30 to 3.19 µg/L (Table 3).

Average concentration of cadmium was found to be 4.33 ± 3.65 µg/L ranging from 0.029 to 17.68 µg/L. Cadmium was present in 76 %, 39 %, 92 % and 86.6 % of the samples of Hajira, Rawalakot, Bagh and Palandari regions respectively. The mean concentration of cadmium was found to be 5.16 ± 4.14 µg/L in Hajira, 4.14 ± 3.07 µg/L in Rawalakot, 4.54 ± 3.91 µg/L in Bagh and 2.48 ± 1.86 µg/L in the samples of Palandari region (Table 3). There was no significant difference of cadmium concentration among the samples of four studied regions. Permissible limit of cadmium in drinking water is 0.003 mg/L i.e. 3 µg/L [9]. Nearly half of the samples (35) of the current study having cadmium concentration within the safe limit set by WHO, while half of the samples (40) had mean concentration of 6.20 µg/L which exceed the safe limit of water recommended by WHO. The high concentration of cadmium in the samples of study region may be attributed to the presence of underground rocks of cadmium in the region from where it enters the spring water. A study conducted by in the water of Phuleli Canal of Sindh, Pakistan, reported the mean value of cadmium to be 0.0032 mg/L (3.2 µg/L) which is quite lower than our study [11].

Mean concentration of chromium in our study was found to be 0.43 ± 0.35 ranging from 0.001 to 2.09 µg/L. Chromium was present in 73.5 %, 51.5 %, 92 % and 86.6 % of the samples of Hajira, Rawalakot, Bagh and Palandari region respectively (Table 3). The mean concentration of chromium was found to be 0.34 ± 0.27 µg/L in Hajira, 0.58 ± 0.27 µg/L in Rawalakot, 0.53 ± 0.45 µg/L in Bagh and 0.26 ± 0.28 µg/L in the samples of Palandari region. Chromium concentration was significantly higher ($p=0.013$) in the samples of Rawalakot region as compared to Palandari but there was no statistical difference among the other regions of study area (Table 3). Permissible limit of chromium is 0.05 mg i.e. 50 µg/L (WHO, 2004) [9]. The chromium concentration in present study was within the safe limit set by WHO. Previously, reported average concentrations of chromium in drinking water of Kohat, Khyber Pakhtunkhwa, Pakistan with the average of 0.001 mg/L (1 µg/L), while the average concentration of chromium in spring water of Stan Terg, Kosovo was found to be 50µg/L [12].

Mean concentrations of copper in our study was found to be 0.39 ± 0.40 ranging from 0.005 to1.78 µg/L. Copper was present in 79 %, 73 %, 68 % and 86.6 % of the samples of Hajira, Rawalakot, Bagh and Palandari region respectively. The mean concentration of copper was found to be 0.49 ± 0.45 µg/L in Hajira, 0.42 ± 0.43 µg/L in Rawalakot, 0.39 ± 0.35 µg/L in Bagh and 0.20 ± 0.24 µg/L in the samples of Palandari. There was no significant difference in copper concentration among the samples of studied regions (Table 3). The permissible limit of copper in drinking water is 2 mg/L = 2000 µg/L [13]. The copper concentration in present study was within the safe limit set by WHO. Mean nickel concentration in our study was found to be 0.56 ± 0.66 µg/L ranging from 0.30 to 3.19 µg/L. Nickel was present in 29, 21 %, 20 % and 13 % of the samples of Hajira, Rawalakot, Bagh and Palandari region respectively.

Mean concentrations of nickel was found to be 0.70 ± 0.95 µg/L in Hajira, 0.65± 0.28 µg/L in Rawalakot, 0.16 ± 0.11 µg/ in Bagh and 0.54 ± 0.63 µg/L in the samples of Palandari region. There was no significant difference found in nickel concentration among the samples of four studied regions (Table 3). Permissible limit of nickel in water is 0.07 mg/L. Nickel concentration in our study was present within the safe limit set by WHO. In past study it was reported the nickel concentration in drinking water of Egypt with average of 48.97 mg/L (48970 µg/L) [13].

Average concentration of lead was found to be 2.77 ± 4.21 µg/L ranging from 0.004 to 19.39 µg/L in current study. Lead was present in 62 %, 70 %, 80 % and 40 % of the samples of Hajira, Rawalakot, Bagh and Palandari respectively. A significance difference (p=0.014) was found among different regions in percentage detection of lead (Table 3). Mean concentrations of lead was found to be 1.56 ± 3.56 µg/L in Hajira, 3.97 ± 5.17 µg/L in Rawalakot, 1.73 ± 1.46 µg/L in Bagh and 5.9 ± 6.26 µg/L in the samples of Palandari. There was a significant difference of Pb concentration among all regions. Lead concentration was significantly higher in the samples of Palandari as compared to the samples of Hajira and Bagh region but it was not different from Rawalakot region (Table 3). Permissible limit of lead is 10 µg/L. The results of our study show that the spring water of Hajira, Rawalakot, Bagh and Palandari are in safe limit for drinking purpose except for three samples having concentrations of 15.85, 19.39 and 16.47 µg/L which exceeds the upper permissible limit of drinking water which is 10 µg/L [9]. In the water of Bannu dam and Damai strean of KPK, Pakistan, the concentration of lead metal is 5.53 mg/L (5530 µg/L) and 5.09 mg/L (5090 µg/L) [14], which is very high as compared to our study as well as higher than the upper boundary of safe limit for drinking water.

Conclusion

Results of the current study showed that physical parameters like total dissolved solids, pH and electrical conductivity are within the permissible limit of drinking water recommended by WHO. The mean concentrations of sodium, potassium, calcium, magnesium, chromium, copper and nickel were found to be 8.33 mg/L, 1.08 mg/L, 13.83 mg/L, 9.72 mg/L, 0.43 µg/L, 0.39 µg/L and 0.56 µg/L respectively. Concentrations of all the metals in all the samples were present within the safe limit of drinking water recommended by the World Health Organization, except for 3 samples of lead and 40 samples of cadmium which had a concentration higher than the upper safe limit. The results of our study show that the spring water of Hajira, Rawalakot, Bagh and Palandari is safe for drinking purpose.

Table 1 Comparison of physical parameters among the studied regions (TDS= Total dissolved solids; ppt = part per million; EC= Electrical conductivity; N=Total no of samples from region)

Parameter		**Overall**	**Hajira (N=34)**	**Rawalakot (N=33)**	**Bagh (N=25)**	**Palandari (N=15)**	**Sig.**
TDS (ppt)	Mean	82.36	83.29^{AB}	76.83^{A}	72.97^{A}	103.79^{B}	***0.004***
	Sd.	29.98	33.77	16.83	18.53	43.22	

	Range	36 -187	10.3-173	36-114	55.9-147.7	56-187	
EC (µS/cm)	Mean	93.35	94.58^{AB}	86.54^{A}	83.56^{A}	117.09^{B}	
	Sd.	32.28	36.02	18.75	20.28	45.74	***0.003***
	Range	12 -207.7	12-202	63.7-131.5	62.9-163.8	60-207.7	
pH	Mean	8.15	8.15	8.16	8.20	8.1	
	Sd.	0.20	0.25	0.20	0.09	0.21	*0.189*
	Range	7.29-8.54	7.54-8.54	7.29-8.43	8.02-8.44	7.66-8.33	

Table 2 Comparison of Na, K, Ca and Mg quantities among the regions and among each other

Metal	**Conc. (mg/L)**	**Overall**	**Hajira (n=34)**	**Rawalakot (n=33)**	**Bagh (n=25)**	**Palandari (n=15)**	**Sig.**	**Limit** (mg/L)**
Na	Mean	8.33	7.80 ^{AB}	8.83 ^{AB}	5.21 ^{A}	12.78 ^{B}	***0.011***	200
	Sd.	7.57	6.50	5.75	2.11	13.44		
	Range	0.11-64	0.11-33.83	0.14-22.67	1.07-9.67	4.66-64		
K	Mean	1.08	1.22	1.12	0.87	1.02	*0.195*	12
	Sd.	0.65	0.67	0.80	0.39	0.50		
	Range	0.15-3.83	0.32-3.83	0.15-3.56	0.37-2.23	0.67-2.43		
Ca	Mean	13.83	13.55	12.81	12.80	17.67	*0.100*	75
	Sd.	7.27	7.97	4.61	3.60	11.72		
	Range	3.85-50.83	4.09-34.38	3.85-25.86	6.27-19.84	4.74-50.83		
Mg	Mean	9.72	10.69 ^{A}	9.57 ^{AB}	8.17 ^{B}	10.27 ^{AB}	***0.018***	
	Sd.	3.17	3.63	3.17	2.51	2.30		150

	Range	1.29-17.18	1.29-15.95	6.87-14.29	1.33-13.21	6.87-14.29	
Sig.		***0.000***					

Table 3: Qualitative and quantitative comparisons of Cd, Cr, Cu, Ni and Pb among each other and among the studied regions (* n= Number of samples out of 110 in which the metal was detected , ** Upper boundary of permissible limit for drinking water set by WHO)

Metals	**Conc. (µg/L)**	**Overall**	**Hajira (N=34)**	**Rawalakot (N=33)**	**Bagh (N=25)**	**Palandari (N=15)**	**Sig.**	**Limit** (µg/L)**
Cd	n*	75 (68 %)	26 (76 %)	13 (39 %)	23 (92 %)	13 (86.6 %)	0.185	3
	Mean	4.33	5.16	4.14	4.54	2.48		
	Sd.	3.65	4.14	3.07	3.91	1.86		
	Range	0.029-17.68	0.03-0.99	0.058-0.99	0.15-2.09	0.001-0.86		
Cr	n*	83 (75 %)	25 (73.5 %)	17 (51.5 %)	23 (92 %)	13 (86.6 %)	***0.013***	50
	Mean	0.43	.34^{AB}	0.58^{B}	0.53^{AB}	0.26^{A}		
	Sd.	0.35	0.27	0.27	0.45	0.28		
	Range	0.001-2.09	0.02-0.99	0.06-0.99	0.15-2.1	0.001-0.86		
Cu	n*	84 (76 %)	27 (79 %)	24 (73 %)	17 (68 %)	13 (86.6 %)	*0.153*	2000
	Mean	0.39	0.49	0.42	0.39	0.20		
	Sd.	0.40	0.45	0.43	0.35	0.24		
	Range	0.005-1.78	0.009-1.7	0.007-1.78	0.005-0.99	0.007-0.88		
Ni	n*	24 (22 %)	10 (29 %)	7 (21 %)	5 (20 %)	2 (13 %)	*0.508*	70
	Mean	0.56	0.70	0.65	0.16	0.54		
	Sd.	0.66	0.95	0.28	0.11	0.63		
	Range	0.30-3.19	0.73-3.19	0.12-0.88	0.30-.27	0.09-0.99		
Pb	n*	70 (64%)	21 (62 %)	23 (70 %)	20 (80 %)	6 (40 %)	***0.038***	10
	Mean	2.77	1.56^{A}	3.97^{AB}	1.73^{A}	5.93^{B}		
	Sd.	4.21	3.56	5.17	1.46	6.26		
	Range	0.004-19.39	0.008-15.85	0.004-19.39	0.052-5.26	0.20-13.33		
Sig.		***0.000***						

References

1. Junaid, M., Youth Activists in Kashmir: State Violence, Tehreek, and the Formation of Political Subjectivity. 2017.
2. Bhateria, R. and D. Jain, Water quality assessment of lake water: a review. Sustainable Water Resources Management, 2016. 2(2): p. 161-173.
3. Moosavirad, S., et al., Removal of some heavy metals from inorganic industrial wastewaters by ion exchange method. Journal of Water Chemistry and Technology, 2015. 37(4): p. 191-199.
4. Kurn, S.J. and S. Shook, Herbs and Nutrients for Neurologic Disorders: Treatment Strategies for Alzheimer's, Parkinson's, Stroke, Multiple Sclerosis, Migraine, and Seizures. 2016: Simon and Schuster.
5. Mastoi, A.A., Comparison between Diabetic Patients and Hepatitis B and C by Clinical Metabolic Investigations. 2012, UNIVERSITY OF SINDH, JAMSHORO-PAKISTAN.
6. Iqbal, H., et al., Physico-chemical analysis of drinking water in district Kohat, Khyber Pakhtunkhwa, Pakistan. International Journal of Basic Medical Sciences and Pharmacy (IJBMSP), 2014. 3(2).
7. Batayneh, A.T., Heavy metals in water springs of the Yarmouk Basin, North Jordan and their potentiality in health risk assessment. International Journal of Physical Sciences, 2010. 5(7): p. 997-1003.
8. Jahangir, T.M., et al., Chemical assessment of natural springs of Sindh Pakistan. Canadian Journal of Pure and Applied Sciences Senra Academic Publishers, British Columbia, 2013. 7(2): p. 2431-2449.
9. santé, O.m.d.l., et al., Guidelines for drinking-water quality. Vol. 1. 2004: World Health Organization.
10. Ahmad, Q.R., M. Kamran, and T. Mohammad, Mineral constituents of health significance of Hazara water supplies. JPMA. The Journal of the Pakistan Medical Association, 1988. 38(4): p. 100-105.
11. Soomro, A., et al., Seasonal variations of trace elements and heavy metal concentrations in Phuleli canal water (Sindh), Pakistan. Sarhad Journal of Agriculture, 2014. 30(1): p. 73-82.
12. Avdullahi, S., et al., Assessment of heavy metal in the water springs, Stan Terg, Kosovo. International Journal of Engineering, 2013. 2(4): p. 2305-8269.
13. Mohamed, R., et al., Determination of trace elements in water and sediment samples from Ismaelia Canal using ion chromatography and atomic absorption spectroscopy. Chemical Speciation & Bioavailability, 2012. 24(1): p. 31-38.
14. Zakir, M., Heavy Metals Analysis of Bannu Dam's and Damai Stream During Breeding Season of Fishes. World Applied Sciences Journal, 2015. 33(12): p. 1842-1845.