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ARTICLE

Evaluation of Heavy Metals in Drinking Water of Tribal Districts Ex-FATA Pakistan

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Abstract

This study was conducted to evaluate the heavy metals such as zinc (Zn), iron (Fe), copper (Cu), nickel (Ni), chromium (Cr), and cadmium (Cd) in seven water samples which were collected from Ex-FATA Pakistan (Bajaur, Mohmand, Khyber, Orakzai, Kurram, South Waziristan and North Waziristan). All samples were digested using the wet digestion method and the digested samples were analyzed for heavy metals using an atomic absorption spectrophotometer. The results of water samples from seven districts were compared to the recommended standard value from the World Health Organization and the Environmental Protection Agency. The results obtained from the analysis for nickel (Ni) showed that the highest concentration (0.093 mg/l) was reported in the water of the Khyber district, while the lowest concentration (0.011 mg/l) was found in the water of the Orakzai district. Iron (Fe) highest concentration (0.86 mg/l) was found in the water of the district Mohmand which was slightly high than the WHO recommended value. The highest concentration (0.19 mg/L) of chromium (Cr) was reported in the water of the Orakzai district. furthermore, the result showed that the highest concentration (0.87 mg/l) of zinc (Zn) was in the Orakzai district, the highest concentration (1.92 mg/l) of copper (Cu) in Khyber and Mohmand districts (1.92 mg/l), while the highest concentration (0.0029 mg/l) of cadmium (Cd) was measured in the water of Orakzai district. After the comparison of all these values to WHO and EPA standard values, this study shows that the water of all these districts is safe for drinking water purposes

Keywords: Drinking water, water quality, heavy metals, human health, environment

1. Introduction

Water is one of the naturally available resources that play a key role in the sustainability of life[1]. Pollutant-free water is a basic need for healthy human life. Toxic heavy metals present in water are very harmful to human health and all living organisms. Some of the heavy metals are required by the human body in small amounts, while their excess leads to dangerous effects on human life. The presence of some heavy metals is very toxic even in very small amounts[2]. Increasing environmental pollution from pollutants is a major concern for local users. Numerous pollutants are regularly introduced into the aquatic environment, mainly as a result of increasing industrialization, technological advances, population growth, resource depletion, and runoff of household and agricultural waste[3]. Increasing environmental pollution from pollutants is a major concern for local users. Numerous pollutants are regularly introduced into the aquatic environment, mainly as a result of increasing industrialization, technological advances, population growth, resource depletion, and runoff of household

and agricultural waste[4]. Increasing environmental pollution from pollutants is a major concern for local users. Numerous pollutants are regularly introduced into the aquatic environment, mainly as a result of increasing industrialization, technological advances, population growth, resource depletion, and runoff of household and agricultural waste[5].

Historically, there have been reports of heavy metals in drinking water covering their types and amounts, as well as origins, human exposure, hazard, and distance. Despite enormous progress, research is still needed to obtain clean drinking water[6]. Due to their limited economic capacity, many low- and middle-income countries are particularly concerned about the problem of reducing small numbers of heavy metals below the proposed limits[7]. A region's medical problems can be found by routinely evaluating the drinking water quality. Because heavy metals are toxic, persistent, and bio accumulative, heavy metal contamination of drinking water and food has become a major concern for environmental professionals worldwide[8].

The drinking water contaminated with heavy metals has not yet been investigated in the study region. To determine heavy metal concentrations in drinking water from seven EX-FATA districts, this study was designed with population, geology, and anthropogenic inputs in mind, the heavy metal concentrations were examined for potential health risks.

2. Materials and Methods

2.1 Samples Collection

Drinking water samples were collected from seven districts of the Ex-FATA. Two water samples were collected at different points from each district and were mixed. The samples were stored in polythene bottles. The samples were collected in the districts showing in figure 1 and table 1.

2.2 Preparation Sample

The samples were taken to the laboratory where they were later digested. 10 ml of the sample, 5 ml of concentrated HNO3 and 5 ml of concentrated HCl were used for the digestion. This combination was left at room temperature for almost an hour after being gently stirred and covered with a watch glass. Then the samples were heated on a hot plate until yellow fumes were generated, and the solution became clear. After cooling, a Millipore filter (0.4µ) was used to filter the acid solution and deionized water was used to bring the volume to 50 mL[9].

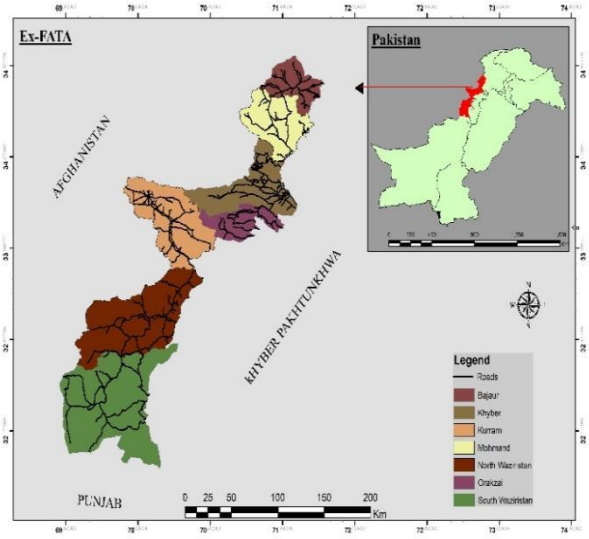

Figure 1. Map representing the districts where samples were collected.

Table 1. Districts and Locations of collected samples.

S.No	District	Location
1	Bajaur	Tehsil Salarzai
2	Mohmand	Tehsil Safi
3	Orakzai	Lower Orakzai
4	North Waziristan	Tehsil Miranshah
5	Khybar	Tehsil Bara
6	Kurram	Lower Kurram
7	South Waziristan	Tehsil Wana

2.3 Preparation of standards

Deionized water was used to dilute several prepared standards of each element (0.1g/100ml; Fisher Chemicals, U.K). Ultra-pure chemicals were used for the analytical analysis. Overall process of research are presented in figure 2.

2.4 Analysis of Heavy metals

Atomic absorption spectrometer (PerkinAnalyst 800 JAPAN) was used for the analysis of heavy metals such as copper (Cu), Iron (Fe), Cadmium (Cd), Chromium (Cr) , Zinc (Zn), and Nickle (Ni).

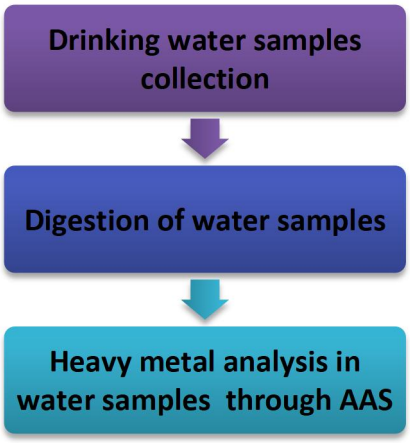

Figure 2. Overall process of research.

3. Results and Discussion

3.1 Concentration of Nickel (Ni):

Nickel is a heavy metal found in the environment such as water, air, and soil. The main sources that generate nickel are the various industries, municipalities, fuels, and industrial effluents[10]. Excessive nickel consumption can cause various diseases in humans such as pulmonary fibrosis, lung cancer, cardiovascular disease, and kidney disease[11]. Figure 3 shows the total concentration of nickel in each water sample, ranging from 0.011 to 0.093 mg/L. The water sample from Khyber district showed the highest concentration with 0.093 mg/L, followed by the water from North Waziristan district and the water from South Waziristan with 0.09 and 0.07 mg/L nickel, which were below that from the WHO recommended value (0.1 mg/L) The lowest concentration of 0.011 mg/L was found in the water of Orakzai district, followed by Bajaur, Mohmand, and Kurram with 0.017, 0.019 and 0.049 mg/L.

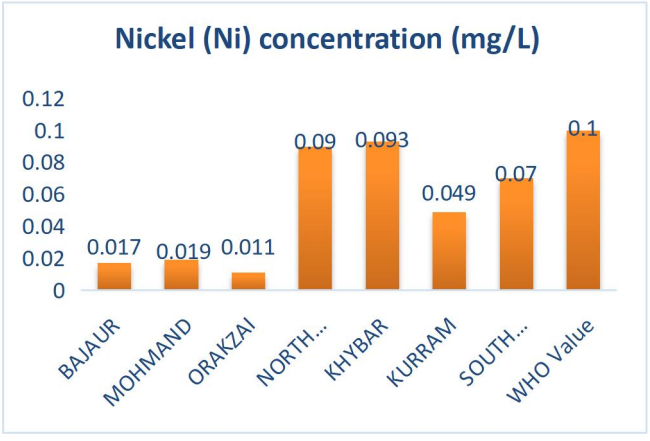

Figure 3. Concentration of Nickel (Ni) in each district water samples.

3.2 Concentration of Iron (Fe):

In the human body, iron is one of the main elements that play a very important role in various reactions in the human body, such as intracellular and oxygen transport[13]. Iron deficiency can cause various types of diseases in humans, including anemia or iron deficiency, although the high levels of iron in water also have adverse effects on humans, leading to heart problems, liver disease, and diabetes[14]. The availability of iron in the soil is also important for plants as it plays an important role in the process of photosynthesis and chlorophyll[15], while the excess/lower iron content in the soil can cause direct damage to plants, including low-fat or protein content, disruption of root viability and cell damage[16]. The level of iron (Fe) in drinking water recommended by the World Health Organization is 0.3 mg/l[17].The results of Fig. 4 shows that all fifteen samples have Fe values ranging from 0.07 mg/L to 0.86 mg/L. The highest concentration, above the WHO recommended level (0.3 mg/L), was found in the drinking water of the Mohmand district (0.86 mg/L) and Orakzai district at 0.32 mg/L, while the lowest concentrations were found in the water of the district Khyber (0.07 mg/L).

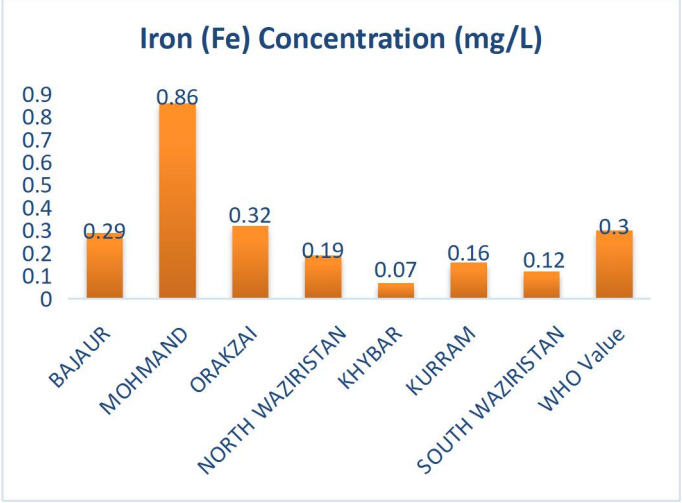

Figure 4. Concentration of Iron (Fe) in each district water samples.

3. 3 Concentration of Chromium (Cr)

Chromium is one of the important heavy metals that play an important role in enhancing the action of insulin and lowering the level of glucose in the human body[18], although its excess intake of chromium can lead to irregular heartbeats, headaches,

allergic reactions, kidney and liver damage[19]. The excess amount of chromium in the soil/water also has adverse effects on plant growth and other important metabolic processes that make plants toxic such as oxidative stress[20]. The WHO recommended level of chromium in water is 0.1 mg/L[21]. The results in Fig. 5 show that all of the water samples from the Orakzai district have a high value of 0.19 mg/l, followed by the water sample from the Mohmand district with 0.16 mg/l, which is slightly above the recommended standard value (0. 1 mg/l). The lowest concentration was recorded in Khyber District (0.07 mg/L), South Waziristan Water District (0.08 mg/L), Bajaur District (0.09 mg/L), and Kurram District (0.1 mg /L) detected.

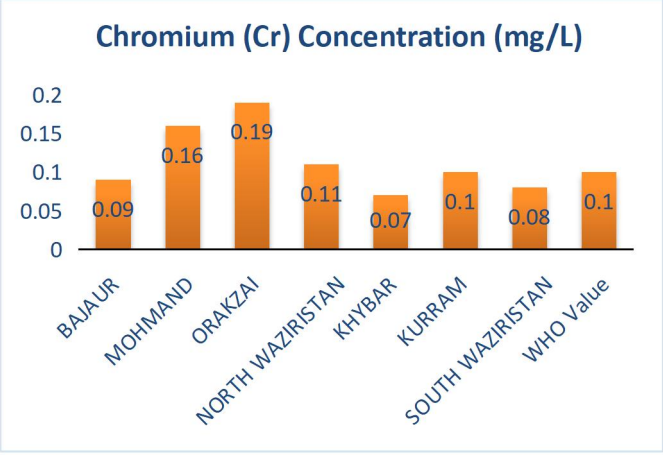

Figure 5. Concentration of chromium (Cr) in each district water samples.

3.4 Concentration of Zinc (Zn):

Zinc is one of the vital heavy metals that play a key role in both humans and plants[22]. Zinc is most abundant in foods that are primarily of animal origin[23]. Low zinc intake can lead to various types of diseases such as wound healing disorders and hypogonadal dwarfism. After taking zinc, it accumulates very quickly in different parts of the body[24]. Excessive intake of zinc has negative effects on humans and plants[25]. The recommended standard value for zinc is 3 mg/L, this standard value is the same for both surface water and groundwater[26]. The results in Fig. 6 show that the concentration value in all water samples is below the recommended standard value, which is between 0.018 mg/L and 0.087 mg/L. The lowest concentration was found in the water of the Bajaur district (0.018 mg/l), while the highest concentration was reported in the water of the Orakzai district (0.087 mg/l).

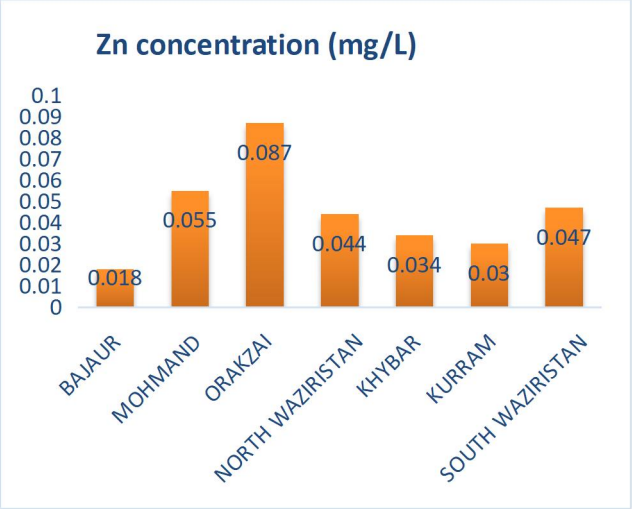

Figure 6. Concentration of Zinc (Zn) in each district water samples.

3.5 Concentration of Copper (Cu):

Copper is one of the most important essential trace elements that play a vital role in the human body[27]. In humans, copper plays an important role in the absorption of iron, the formation of red blood cells, and the maintenance of the immune system and nerve cells[28], while too high or too low levels of copper can cause severe damage to the brain, heart, and kidneys in humans[29]. According to the WHO, the recommended standard range for copper water is 2 mg/L. The result in Fig. 7 shows that the copper concentration in all water samples was below the recommended standard value.

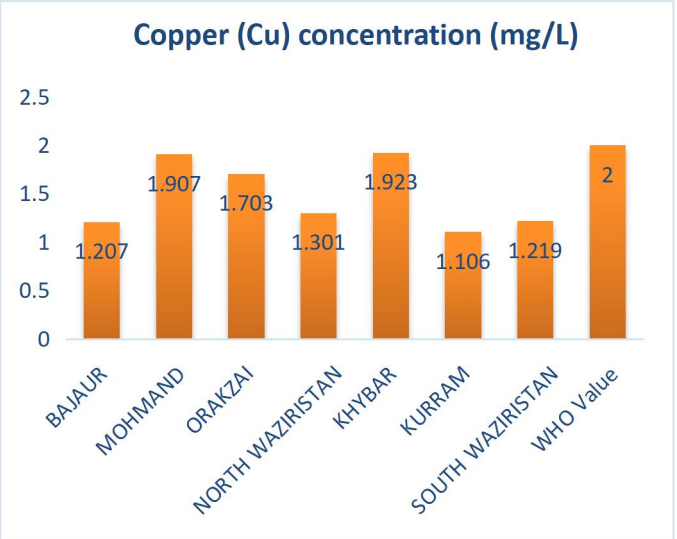

Figure 7. Concentration of Copper (Cu) in each district water samples.

3.6 Concentration of Cadmium (Cd):

Cadmium is one of the toxic heavy metals that are toxic to humans in the long and short term[30]. Intake of cadmium in food and water can cause severe harmful effects on humans like intestinal diseases and kidney damage [31]. According to the world health organization, the recommended safe level of cadmium in water is 0.003 mg/L [32]. The results in Fig. 8 show that the cadmium levels in all water samples are below the WHO-recommended standard level of safe drinking water.

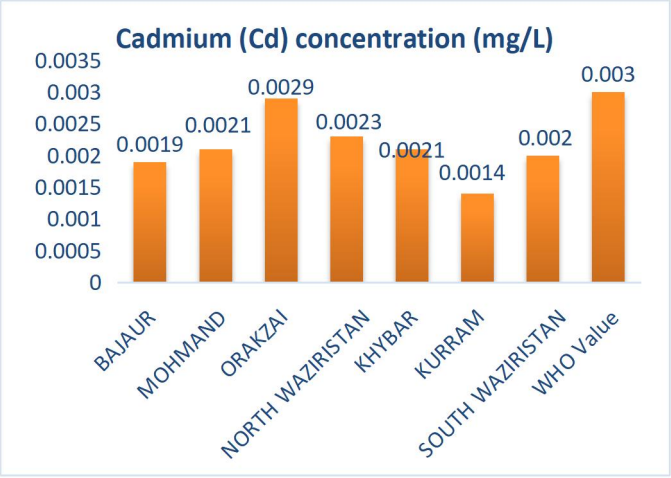

Figure 8. Concentration of Cadmium (Cd) in each district water samples.

4. Conclusion

This study was conducted to evaluate the concentration of six heavy metals in drinking water from Ex-FATA seven districts (Bajaur, Mohmand, Orakzai, Kurram, Khyber, South Waziristan, and North Waziristan). Drinking water samples from the groundwater of the tested sites, after careful examination and comparison with the recommended WHO standard values, the results of this study show that the water in these areas is not carcinogenic and is suitable for both drinking and agricultural use.

Authors Contribution

R.U and M.S supervised the research work, wrote the Manuscript, and has the main idea and NN, AN, KA and KB helps in lab work and samples collection. HF, ZAS, MNA, YA, revised the manuscript and provided suggestions

Conflicts of Interest

There are no conflicts of interest reported by the writers.

Data Availability statement

The data presented in this study are available on request from the corresponding author.

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