EurJChem An International Open Access Journal

European Journal of Chemistry

ATLANTA PUBLISHING HOUSE

Check for updates

View Journal Online
View Article Online

Heavy metal concentrations in drinking water in the region north-east of Jhunjhunu, Rajasthan, India

Anil Kumar *

Department of Chemistry, Rakesh Post Graduate College Pilani, Jhunjhunu, Rajasthan 333031, India

* *Corresponding author at: Department of Chemistry, Rakesh Post Graduate College Pilani, Jhunjhunu, Rajasthan 333031, India.*
e-mail: annukhed1@gmail.com (A. Kumar).

RESEARCH ARTICLE

10.5155/eurjchem.14.3.348-352.2435

Received: 22 March 2023
Received in revised form: 07 May 2023
Accepted: 29 May 2023
Published online: 30 September 2023
Printed: 30 September 2023

KEYWORDS

Iron
Copper
Rajasthan
Groundwater
Trace elements
Atomic absorption spectrometer

ABSTRACT

Groundwater is contaminated by undesirable elements that are introduced directly or indirectly into a natural water reservoir supplied by human activity, thus changing its physico-chemical properties. The north-east of Jhunjhunu in Rajasthan state of India was chosen as the study area due to the lack of research evidence in the past. The heavy metal content of a total of 42 water samples was analysed using an atomic absorption spectrometer. The copper and iron content in the groundwater of the study area is revealing a spatial distribution range of 1.75 to 4.01 mg/L for copper and 0.44 to 1.22 mg/L for iron. The obtained result was compared with Buero of Indian Standard (10500:2012), Indian Council of Medical Research, and World Health Organisation. There are iron and copper mining facilities in the studied area. Therefore, the concentration of both minerals was observed in the groundwater of all sampling stations. The iron and copper content are much higher in groundwater than the permissible limit of Buero of Indian Standard and World Health Organisation. The manganese content was not detected at all sampling sites. Both iron and copper elements are trace elements, and their higher concentration has proven to be a major problem and there are many health risks associated with it. These observed concentrations indicate a hazardous risk to human health. The official authorities should take the necessary measures in this regard.

Cite this: *Eur. J. Chem.* **2023**, *14(3)*, 348-352 **Journal website**: www.eurjchem.com

1. Introduction

Today, our world is moving towards a big problem caused by the lack of quality and quantity of water [1]. Research on the quality and quantity of groundwater is a bit disappointing. Several researchers from all over India and organisations like the Central Board of Groundwater are conducting various research works using different techniques on groundwater for its water quality [2]. Regarding quality, major elements still provide quality parameters for drinking water, in particular, heavy metal concentrations are also observed and reported due to their toxic nature [3]. Some trace elements, such as Fe and Cu, which are in excess or deficient in groundwater, are required for drinking for biological purposes and play an important role in human life [4-6].

We know that the study area is well known for its metallic resources, the subsurface is rich in various metallic ores [6], and a copper mine (Khetri Copper Complex, Singhana, Rajasthan, India) is operational in the region. Thus, various metal ions such as copper and iron mix with groundwater and pollute groundwater. The previous study on groundwater in this area has confirmed the same inference [7]. In the present study, 42 groundwater samples were collected from different locations of the Chirawa, Buhana, and Surajgarh divisions of the Jhunjhunu district, India. All samples were analysed for their heavy metals and compared with the quality of groundwater of Buero of Indian Standard (BIS) (10500:2012) [8], Indian Council of Medical Research (ICMR) [9] and World Health Organization (WHO) [10,11].

2. Experimental

2.1. Study area

The present study was conducted on Chirawa, Buhana, and Surajgarh tehsils of Jhunjhunu district, Rajasthan, India. Forty-two sampling sites were selected for the present study (Figure 1). Groundwater samples were collected at the 42 sampling sites mentioned in Table 1 along with their GPS coordinates (Figure 2).

2.2. Groundwater sample collection

Groundwater samples were collected in dark plastic bottles. All 42 samples were collected from different villages of three Tehsils (Chirawa, Buhana, and Surajgarh). All samples were collected in August 2019. The samples were filtered through Whatman No:41 filter paper and protected from sunlight.

ISSN 2153-2249 (Print) / ISSN 2153-2257 (Online)
https://dx.doi.org/10.5155/eurjchem.14.3.348-352.2435

Table 1. Sampling sites and their respective codes and tehsils.

Sample code	Sampling site	Tehsil	GPS coordinates	Sample code	Sampling site	Tehsil	GPS coordinates
S1	Pilani Water Box	Surajgarh	28.3662843, 75.6129504	S22	Pilod	Surajgarh	28.128864, 75.769185
S2	Pilani Bus Stand	Surajgarh	28.3622899, 75.5955495	S23	Bhavthari	Surajgarh	28.096078, 75.839313
S3	Pilani Birla Hospital	Surajgarh	28.358872, 75.604878	S24	Bijoli	Surajgarh	28.121643, 75.945076
S4	Jherli	Surajgarh	28.36899698, 75.5597608	S25	Kajara	Surajgarh	28.142821, 75.946539
S5	Hameenpur	Surajgarh	28.425532, 75.6483049	S26	Jeeni	Surajgarh	28.1688817, 75.9158331
S6	Bangothari Kalan	Surajgarh	28.462242, 75.632749	S27	Narhar	Chirawa	28.2035058, 75.8714355
S7	Beri	Surajgarh	28.493684, 75.629309	S28	Ojtu	Chirawa	28.226871, 75.930684
S8	Dulania	Surajgarh	28.407939, 75.690935	S29	Chirawa Water Box	Chirawa	28.2354236, 75.8527637
S9	Dheendhwa Aguna	Surajgarh	28.351211, 75.632339	S30	Chirawa CHC	Chirawa	28.2466478, 75.8228379
S10	Morwa	Surajgarh	28.393457, 75.661337	S31	Chirawa Station	Chirawa	28.2638235, 75.7868353
S11	Kherla	Surajgarh	28.341840, 75.602947	S32	Ardawata	Chirawa	28.2742448, 75.7550625
S12	Devrod	Surajgarh	28.292328, 75.593946	S33	Chirawa RIICO	Chirawa	28.297956, 75.731273
S13	Lakhu	Surajgarh	28.306866, 75.627469	S34	Gadakhera	Chirawa	28.304025, 75.727695
S14	Chorodi Auguni	Surajgarh	28.223546, 75.616880	S35	Bhasawata Kalan	Buhana	28.301531, 75.729803
S15	Khedaro ki Dhani	Surajgarh	28.232373, 75.647143	S36	Singhana	Buhana	28.3299358, 75.8023113
S16	Kakoda	Surajgarh	28.241195, 75.651686	S37	Pacheri khurd	Buhana	28.355198, 75.731698
S17	Surajgarh R. Station	Surajgarh	28.222810, 75.649225	S38	Pacheri Bari	Buhana	28.3783602, 75.7792011
S18	R.K.J.Kishor Barasia College	Surajgarh	28.184429, 75.629968	S39	Bhirr	Buhana	28.3787655, 75.8006926
S19	Surajgarh Mandi	Surajgarh	28.219714, 75.659279	S40	Buhana	Buhana	28.3801416, 75.7479392
S20	Jakhod	Surajgarh	28.218566, 75.681081	S41	Dhaka Mandi	Buhana	28.3450231, 75.6977906
S21	Farat	Surajgarh	28.177983, 75.737789	S42	Badbar	Buhana	28.3246749, 75.6741614

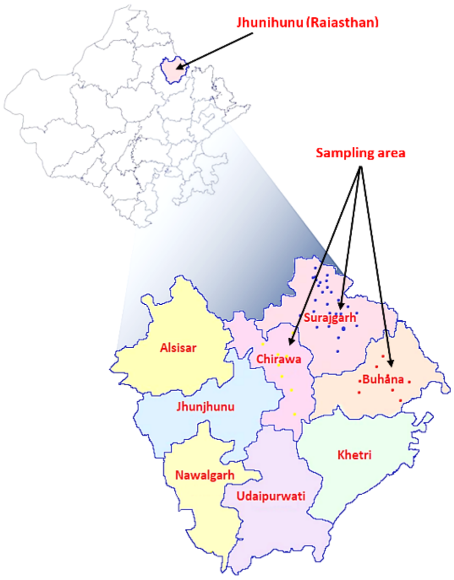

Figure 1. Research area of three tehsils of Jhunjhunu district, Rajasthan, India.

The samples were acidified with 5 ml of concentrated nitric acid to prevent precipitation and avoid microbial activity; after that the samples were stored at 4 °C until the analysis was complete.

2.3. Detection of heavy metals by atomic absorption spectrometer

All groundwater samples were analysed for the presence of heavy metals, *viz*. copper, iron, and manganese. The samples were analysed using an atomic absorption spectrometer (Make: Perkin-Elmer, Model: 3030 A) (AAS) [12,13].

2.4. Sample preparation and procedure

At first 50 ml of water sample was taken and 15 ml of concentrated HNO_3 was added to it and carefully mixed. The mixture was boiled on the hot plate until its volume reduced to 25% and was colourless. When the solution was cooled, the volume was set to 100 ml with distilled water and kept for 12 hours. The samples were filtered using Whatman filter paper, and the filtrate was stored in a neat and clean plastic bottle for analysis. All standard solutions of Cu, Fe, and Mn were prepared and used for calibration. An atomic absorption spectrometer (Perkin-Elmer, 3030 A) equipped with hollow cathode lamps was used for the analysis. Each metal was detected at different wavelengths of light. The lamp current was set at 15 mA. The flame composition was propane and isobutane, and the gas pressure is 0.1 kg/cm^2 while the air pressure is 1.5 kg/cm^2. The amount of metal in the water sample was calculated using a standard solution [1,5,14].

3. Results and discussion

In the present study, trace elements viz. copper, manganese, and iron were detected by atomic absorption spectrometer and compared with the permissible limits as set by Buero of Indian Standard (BIS) (10500:2012), Indian Council of Medical Research (ICMR) and World Health Organization (WHO) (Table 2).

Copper compounds find extensive applications across a range of industries and processes. They are utilized as active ingredients in fungicides, algicides, insecticides, and wood preservatives to combat fungal, algal, and insect-related issues. In addition, copper compounds play a vital role in various industrial practises, such as electroplating, azo dye manufacturing, engraving, lithography, petroleum refining, and pyrotechnics.

Table 2. Standards for drinking water.

Parameters	BSI (10500:2012) [8]		ICMR [9]		WHO [10,11]	
	Permissible	Excessive limit	Permissible	Excessive limit	Permissible	Excessive limit
Copper	0.05	1.5	1.0	3.0	1.0	1.5
Iron	0.30	1.0	0.3	1.0	0.3	1.0
Manganese	0.10	0.5	0.1	0.5	0.1	0.5

* Unit: mg/L.

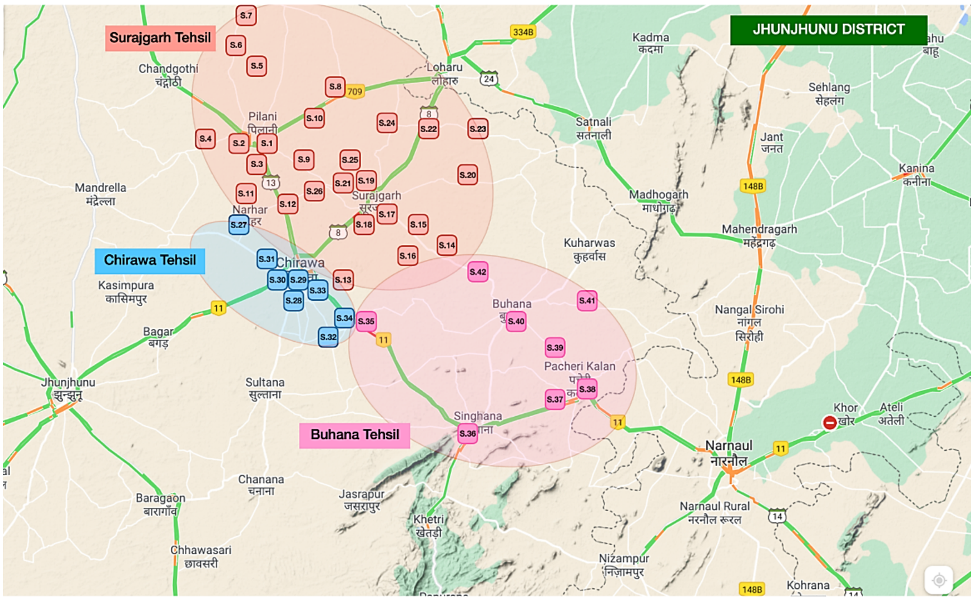

Figure 2. Sampling sites and their respective geographic locations.

Copper compounds also serve as important additives in fertilizers and animal feed. When incorporated into fertilizers, these compounds provide essential copper nutrients to support healthy plant growth. Similarly, copper compounds added to animal feed serve as vital micronutrients, aiding in animal growth and overall well-being. The versatility of copper compounds allows for their widespread use in diverse industries, contributing to the agricultural, manufacturing, and chemical sectors, as well as supporting the growth and development of plants and animals [15-20]. The investigation conducted focused on analysing the copper content in the groundwater of the study area, revealing a spatial distribution range of 1.75 to 4.01 mg/L. Specifically, the tehsil Surajgarh (S1 - S26) exhibited a diverse range of copper content values in the groundwater, spanning from 1.75 to 3.88 mg/L, as documented in Table 3. This indicates significant variability in copper concentrations within the Surajgarh tehsil. Additionally, within the Buhana tehsil (S35 - S42), the groundwater samples showed the highest recorded copper content values, ranging from 3.15 to 4.01 mg/L, as presented in Table 4. On the other hand, Chirawa tehsil (S27 - S34) exhibited relatively moderate copper content values in groundwater, ranging from 2.17 to 3.09 mg/L, as detailed in Table 5. These findings suggest a notable variation in the spatial distribution of copper content within the study area, with higher concentrations observed in tehsil Buhana and more moderate levels in tehsil Chirawa. The results contribute to understanding the copper dynamics in the groundwater and provide valuable insights for further analysis and assessment of water quality in the region. These obtained levels of copper content are much higher than the permissible limit in drinking water as a specification given by the BIS (0.05 mg/L), ICMR (1.0 mg/L) and WHO (1.0 mg/L). In the investigation of copper content in groundwater, notable variations were observed among the sampling sites within the study area. Among the sampled locations, sampling site S3, which belongs to tehsil Surajgarh as documented in Table 3, displayed the lowest recorded copper content value of 1.75 mg/L. Conversely, sampling site S42, belonging to tehsil Buhana as presented in Table 4, exhibited the highest recorded copper content value of 4.01 mg/L. These findings highlight significant differences in copper concentrations within the respective tehsils. Furthermore, it is worth noting that 21 out of the 42 sampled sites demonstrated copper concentrations in groundwater exceeding the threshold of 3.0 mg/L. These results indicate a substantial proportion of sampling sites with elevated copper levels, suggesting the presence of potential concerns regarding water quality and environmental impact. These findings provide valuable scientific insights into the spatial distribution of copper content in groundwater, emphasizing the need for further investigation and monitoring to assess potential risks and ensure the safety of the water supply in the study area. The higher concentration of copper in drinking water has several environmental and health implications. The high amount of copper in drinking water can sometimes impart a light blue or blue-green colour and an unpleasant metallic and bitter taste to drinking water [21]. The high concentration of iron in drinking water can cause gastrointestinal bleeding, haematuria, intravascular haemolysis, methemoglobinemia, hepatocellular toxicity, acute renal failure, and oliguria [22].

Iron is the second most abundant metal in the Earth's crust, accounting for approximately 5%. In the drinking water supply, the iron salts are unstable and precipitated as insoluble iron(III) hydroxide, which settles out as a rust-coloured silt. The aeration of iron-containing layers in the soil can affect the quality of both groundwater and surface water if the groundwater table is lowered or nitrate leaching occurs [23-25]. In the study area, the iron content in the groundwater exhibits a spatial distribution ranging from 0.44 to 1.22 mg/L. Specifically, the Surajgarh tehsil (S1 - S26) demonstrates a wide range of iron content values (0.44 - 1.22 mg/L) (Table 3).

Table 3. Tehsil Surajgarh ascending order of content in ground water.

Samples	Copper concentration, mg/L	Samples	Iron concentration, mg/L
S3	1.75 (Minimum)	S1	0.44 (Minimum)
S4	1.88	S4	0.45
S1	1.95	S10	0.52
S2	1.97	S2	0.65
S5	2.05	S3	0.66
S11	2.15	S11	0.69
S10	2.22	S12	0.73
S24	2.34	S8	0.77
S25	2.55	S24	0.77
S9	2.74	S13	0.79
S23	2.85	S5	0.82
S26	2.87	S6	0.82
S6	2.88	S7	0.82
S12	2.95	S25	0.82
S8	3.08	S9	0.85
S13	3.12	S21	0.85
S21	3.12	S20	0.88
S22	3.16	S23	0.93
S7	3.19	S26	0.93
S20	3.45	S15	0.98
S19	3.55	S17	1.01
S16	3.68	S22	1.01
S15	3.81	S16	1.02
S18	3.86	S19	1.08
S14	3.88 (Maximum)	S18	1.12
S17	3.88 (Maximum)	S14	1.22 (Maximum)
Average	2.84	Average	0.83

Table 4. Tehsil Buhana ascending order of content in ground water.

Samples	Copper concentration, mg/L	Samples	Iron concentration, mg/L
S35	3.15 (Minimum)	S35	0.65 (Minimum)
S37	3.15	S36	0.77
S36	3.22	S37	0.82
S38	3.55	S41	0.92
S40	3.55	S38	0.96
S39	3.68	S40	1.12
S41	3.85	S42	1.15
S42	4.01 (Maximum)	S39	1.18 (Maximum)
Average	3.50	Average	0.96

Table 5. Tehsil Chirawa ascending order of content in ground water.

Samples	Copper concentration, mg/L	Samples	Iron concentration, mg/L
S28	2.17 (Minimum)	S33	0.54 (Minimum)
S29	2.29	S27	0.56
S33	2.35	S30	0.66
S32	2.42	S32	0.67
S31	2.45	S34	0.72
S30	2.73	S28	0.76
S27	2.97	S31	0.78
S34	3.09 (Maximum)	S29	0.81 (Maximum)
Average	2.54	Average	0.69

Tehsil Buhana (S35 - S42) displays a higher iron content value in the groundwater (0.65 - 1.18 mg/L) (Table 4), while tehsil Chirawa (S27 - S34) exhibits relatively moderate iron content values (0.54 - 0.81 mg/L) (Table 5). All these values are higher than the allowed limit in the specification of drinking water given by BIS (0.3 mg/L), ICMR (0.3 mg/L), and WHO (0.3 mg/L). In particular, sampling site S1, located in tehsil Surajgarh and documented in Table 3, exhibited the lowest recorded iron content value of 0.44 mg/L. Conversely, sampling site S14, also belonging to tehsil Surajgarh, displayed the highest recorded iron content value of 1.22 mg/L. These findings indicate a significant variation in iron content within the same tehsil. Furthermore, within the Buhana tehsil (as shown in Table 4), sampling sites S42 and S39 demonstrated relatively higher iron content values, measuring 1.15 and 1.18 mg/L, respectively. Furthermore, sampling site S29, belonging to tehsil Chirawa (as depicted in Table 5), exhibited a comparable higher iron content value of 0.81 mg/L. These observations suggest notable spatial heterogeneity in the distribution of iron content in groundwater across different sampling sites within the study area. The higher concentration of iron in drinking water has several environmental and health implications. High amounts of iron in drinking water can enhance the growth of bacteria and other unicellular organisms [21]. It can change the natural taste of the water and make it undrinkable. The high concentration of iron in drinking water can cause nausea, abdominal pain, and vomiting in the human population. Iron poisoning can also lead to diarrhea and dehydration. Sometimes too much iron causes the stool to become black and bloody [21].

Given the study area's recognized abundance of metallic resources, the sub-surface region is characterized by a substantial presence of diverse metallic ores [6]. Additionally, the region is host to an active copper mine, namely the Khetri Copper Complex in Khetri. Consequently, percolation and leaching processes contribute significantly to the introduction of various metallic ions into the groundwater, leading to the substantial presence of iron and copper in the study area's groundwater. Previous investigations focusing on the groundwater of this area have consistently confirmed these findings [7]. Therefore, it can be inferred that the groundwater in the study area carries a significant concentration of iron and copper, owing to the prevailing geological conditions and anthropogenic activities associated with mining operations.

These results highlight the need for continued monitoring and assessment of the groundwater quality to address potential environmental and human health concerns stemming from the presence of these abundant metallic ions.

4. Conclusion

The present research work carried out to obtain the water quality parameters of the groundwater of the tehsils Surajgarh, Chirawa and Buhana of districts Jhunjhunu, Rajasthan. The study found the following conclusions; (i) The groundwater of the study area exhibiting the values higher than the permissible limit, specified by the BIS for physico-chemical parameters such as iron and copper metals. (ii) The high concentration of iron and copper in all the samples reveals that the study area is suffering from the toxicity of such chemical substances. (iii) The tehsil-wise analysis of the physico-chemical parameters reveals that Surajgarh tehsil (S1 to S26) is exhibiting the more diverse values for the various physico-chemical parameters. Besides, Chirawa tehsil (S27 to S34) is exhibiting the modest values and Buhana tehsil (S35 to S42) is exhibiting the higher values for the various physico-chemical parameters. Accordingly, the ground-water of the Buhana tehsil is less suitable for the drinking purpose. (iv) All the sampling sites are exhibiting the values higher than the permissible limit, specified by the BIS (2012), ICMR, and WHO, it is indicating that this region is under the sever water stress. The human being of the region should be educated for the water treatment and conservation strategies. Largely, all the sampling sites are exhibiting the diversified values for the copper content. It can be inferenced that entire region are rich in the copper content in the drinking water, and it is suggested for remedial measure such as pre-treatment of water before consumption.

Disclosure statement

Conflict of interests: The author declares that they have no conflict of interest.
Ethical approval: All ethical guidelines have been adhered.

ORCID and Email

Anil Kumar
annukhed1@gmail.com
https://orcid.org/0000-0003-0703-0010

References

[1]. Mahdi, A. J.; Ewadh, H. M.; Satee, S.; Salman, J. M.; Brahmaji Rao, P. Comprehensive study of heavy metal pollution in surface water of Guntur region of Andra Pradesh. *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *1088*, 012016.
[2]. Parihar, K.; Sankhla, M. S.; Kumar, R.; Singh, A. Assessment of Copper and Iron concentration in water of Yamuna river, Delhi, India. *Lett. Appl. Nanobioscience* **2020**, *10*, 2251–2257.
[3]. Viswanathan, G.; Jaswanth, A.; Gopalakrishnan, S.; Siva Ilango, S.; Aditya, G. Determining the optimal fluoride concentration in drinking water for fluoride endemic regions in South India. *Sci. Total Environ.* **2009**, *407*, 5298–5307.
[4]. Galitskaya, I. V.; Mohan, K. R.; Krishna, A. K.; Batrak, G. I.; Eremina, O. N.; Putilina, V. S.; Yuganova, T. I. Assessment of soil and groundwater contamination by heavy metals and metalloids in Russian and Indian megacities. *Procedia Earth Planet. Sci.* **2017**, *17*, 674–677.
[5]. Sridhar, S. G. D.; Sakthivel, A. M.; Sangunathan, U.; Balasubramanian, M.; Jenefer, S.; Mohamed Rafik, M.; Kanagaraj, G. Heavy metal concentration in groundwater from Besant Nagar to Sathankuppam, South Chennai, Tamil Nadu, India. *Appl. Water Sci.* **2017**, *7*, 4651–4662.
[6]. Sarkar, S. C.; Dasgupta, S. Geologic setting, genesis and transformation of sulfide deposits in the northern part of Khetri copper belt, Rajasthan, India - an outline. *Miner. Deposita* **1980**, *15*, 117–137.
[7]. Hussain, I.; Hussain, J.; Arif, M.; Vadiya, V. Impact of copper mines and smelter on groundwater quality (Case Study: Rajasthan State in India). *Pollution* **2015**, *1(2)*, 151–163.
[8]. Buero of Indian Standard (BIS) (10500:2012). https://www.bis.gov.in, http://cgwb.gov.in/documents/wq-standards.pdf (accessed May 26, 2023).
[9]. Indian Council of Medical Research (ICMR). Manual of Standards of Quality for Drinking Water Supplies, (1975). https://www.icmr.gov.in, (accessed May 26, 2023).
[10]. WHO (2004) Copper in drinking-water, background document for preparation of WHO Guideline for drinking water quality. Geneva. World Health Organization. (WHO/SDE/WSH/03.04/88)
[11]. WHO (2004) Iron in drinking-water, background document for preparation of WHO Guideline for drinking water quality. Geneva. World Health Organization. (WHO/SDE/WSH/03.04/88)
[12]. Welz, B.; Sperling, M. *Atomic Absorption Spectrometry*; Welz, B.; Sperling, M., Eds.; 3rd ed.; Wiley-VCH Verlag: Weinheim, Germany, 1998.
[13]. *Atomic Absorption Spectrometry: Volume: Theory, Design and Applications*; Haswell, S. J., Ed.; Elsevier Science: London, England, 1991.
[14]. Nazir, R.; Khan, M.; Masab, M.; Rehman, H. U. R.; Rauf, N. U. R.; Shahab, S.; Ameer, N.; Sajed, M.; Ullah, M.; Rafeeq, M.; Shaheen, Z. Accumulation of Heavy Metals (Ni, Cu, Cd, Cr, Pb, Zn, Fe) in the soil, water and plants and analysis of physico-chemical parameters of soil and water Collected from Tanda Dam kohat. *J. Pharm. Sci. Res. 7 (3)*, 89-97 https://www.jpsr.pharmainfo.in/Documents/Volumes/vol7issue03/jpsr07031501.pdf.
[15]. Agrios, G. N. *Plant Pathology*; 5th ed.; Academic Press: San Diego, CA, 2005.
[16]. *Extractive Metallurgy of Copper*; 5th ed.; Elsevier/The Lancet: London, England, 2011.
[17]. Ullmann, F. *Ullmann's encyclopedia of industrial chemistry: Chlorophenols to copper compounds v. A7*; Arpe, H. J.; Biekert, E.; Davis, H. T.; Gerhartz, W.; Gerrens, H.; Keim, W.; McGuire, J. L.; Mitsutani, A.; Pilat, H.; Reece, C.; Simmons, H. E.; Weise, E.; Wirtz, R.; Wüthrich, H. R., Eds.; 5th ed.; Wiley-VCH Verlag: Weinheim, Germany, 1986.
[18]. Suttle, N. *Mineral nutrition of livestock*; 5th ed.; CABI Publishing: Wallingford, England, 2022.
[19]. Landner, L.; Lindestrom, L. *Copper in society and in the environment. (SCDA S-721 88)*; Vasteras, Swedish Environmental Research Group (MFG): Swedish, 1999.
[20]. Shorrocks, V.; Alloway, B. *Copper in plant, animal and human nutrition*; Deutsches Kupfer-Institut, 1986.
[21]. Jaishankar, M.; Tseten, T.; Anbalagan, N.; Mathew, B. B.; Beeregowda, K. N. Toxicity, mechanism and health effects of some heavy metals. *Interdiscip. Toxicol.* **2014**, *7*, 60–72.
[22]. Agarwal, S. K.; Tiwari, S. C.; Dash, S. C. Spectrum of poisoning requiring haemodialysis in a tertiary care hospital in India. *Int. J. Artif. Organs* **1993**, *16*, 20–22.
[23]. Ronov, A. B.; Yaroshevsky, A. A. Chemical composition of the earth's crust. In *The Earth's Crust and Upper Mantle*; American Geophysical Union: Washington, D. C., 2013; pp. 37–57.
[24]. Kumar, P. J. S.; Kokkat, A.; Kurian, P. K.; James, E. J. Nutrient chemistry and seasonal variation in the groundwater quality of a Riverine Island on the west coast of Kerala, India. *Sustain. Water Resour. Manag.* **2020**, *6*, 3.
[25]. Zhu, K.; Hopwood, M. J.; Groenenberg, J. E.; Engel, A.; Achterberg, E. P.; Gledhill, M. Influence of pH and dissolved organic matter on iron speciation and apparent iron solubility in the Peruvian shelf and slope region. *Environ. Sci. Technol.* **2021**, *55*, 9372–9383.