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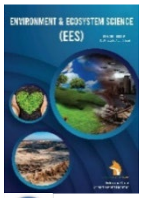

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RESEARCH ARTICLE

ANALYSIS OF DRINKING WATER QUALITY USING HEAVY METAL POLLUTION INDEX (HPI) IN SECTOR H-13, ISLAMABAD, PAKISTAN

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ABSTRACT

This study accesses the quality of drinking water filtration plants in sector H-13, in Islamabad, Pakistan. The objective of this study focuses on the calculation of heavy metals pollution index in the samples collected for the analysis. The results are derived on the basis of physio-chemical and heavy metals parameters, a total 10 numbers of samples were tested for the analysis, to evaluate the quality and standard for the drinking water for human consumption. The physical parameters were studied using the portable instruments, chemical parameters were test using titration instruments, and Flame Atomic Absorption Model AA-7000 by Perkin Elmer were utilized to study the heavy metals parameters. Results shows that most of the samples for physical parameters are within the limit of WHO and PAK-EPA, except the sample TIR-6, which shows the high concentration of total dissolved solids, else the chemical parameters results shows that the concentration of total hardness and Mg ions were high than the prescribed limit in TIR-6 and TIR-9, heavy metals analysis shows that the pollution index is higher in 5 obtained samples, that were above the prescribed limit, for the cadmium, arsenic and lead. The calculation of Heavy metal pollution index indicates that majority of the filtration plants in the sector were highly subjected to contamination and are unsuitable for the consumption purposes.

KEYWORDS

World Health Organization, Pakistan Environmental Protection Agency, Heavy Metal Pollution Index.

1. INTRODUCTION

Water is vital in the provision of healthy lives and thus essential to mankind, but the presence of heavy metals is a high threat globally. Intake of drinking water that contain some metals like lead, cadmium, arsenic, chromium, and iron affects the human health by causing neurological, renal and cardiovascular complications (Alam, 2017). Heavy metal pollutants in Pakistan at the present time have become more common primarily because of urbanization, industrialization, and automobiles which are present in larger concentration in mega cities like Islamabad. Sector H-13 as a part of Islamabad has also seen different levels of heavy metal pollution in drinking water sources due to rapid urbanization and the increase of industries in the area and many residents are at risk (Treacy, 2019). Contamination from heavy metals in drinking water is also documented in many countries in the world. It was found that contamination is highly related to urban and industrial activities mainly because of improper waste disposal (Chaudhary et al., 2024).

A study that the groundwater of Karachi contains higher concentrations of lead and cadmium, so a continuous surveillance and treatment of water is required (Shakoor et al., 2015). Research work conducted in various cities of South Asia has also shown that HPI is useful in cumulative contamination because it gives a summative view of water quality (Siddique et al., 2023). The research was undertaken in DHA phase-II, Islamabad, to provide significant insights for water quality testing by using various factors and piper analysis to link water quality. The purpose of this research was to evaluate the performance of the sector's filtration plants by administering various tests on water samples (Ahmed et al., 2023). A same suggested the filtration plants should utilize high-quality filter paper and regularly replace their membranes for their assessment conducted in Islamabad for the physio-chemical parameters (Ahmed et al., 2024).

The HPI method is applied for the assessment of heavy metal pollution in water resources because of its simplified procedure and inclusion of multiple indices of contamination. For instance, A group concluded that, this HPI method; are useful in pinpointing the areas with more heavy metals in order to enhance the application of relevant control strategies (Ahamad et al., 2020). The has study on heavy metal pollution in filtration plants revealed alarming concentrations of cadmium, chromium, lead, zinc, iron, manganese, and nickel. (Ahmed et al., 2024). These concentrations exceeded PAK-EPA standards, posing a significant risk to human health (Ahmed et al., 2023). Most of researcher also noted that while analysis of the water quality in Pakistan could elicit enthusiasm, it revealed that only a quarter of the population in that country has dependable access to safe drinking water (Hashmi et al., 2009). This study in particularly focuses on the assessment of the quality of drinking water with respect to heavy metal pollution, the mathematical model, used to explain various zones of contamination with regard to specific metal hazardous. Besides, thus, the primary and secondary inspection was also made to see the effects of all the studied pollutants in general. This study aims to highlight the heavy metals pollution index of the filtration plants in the sector, by testing different parameters. The main objective is to calculate the heavy metal pollution index for each sample tested.

1.1 Study Area

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Geographically the area lies to the north-western edge of the city, the prevailing lithology and geological characteristics mark most of the sector as the recent deposits, samples collected from each source filtration plants, with proper marking of coordinates shown in Figure. 1.

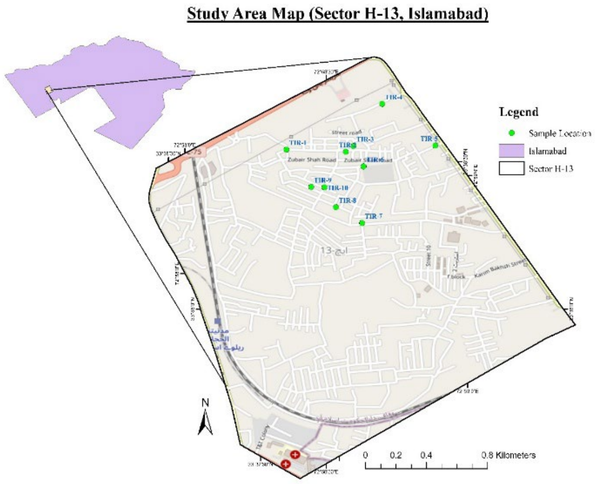


Figure 1 : Study Area Map showing Sample Location Sites in Sector H-13, Islamabad.

2. Methodology

2.1 Sample Preservation and Storage

In the assessment of several factors in water samples three various bottles were used. The physical and chemical qualities of water were investigated in polyethylene bottles as recommended by most of researchers while analysis of heavy metals was in plastic bottles as described by(Muhammad et al., 2011;Khan et al., 2013).

The pH, TDS, and EC were analyzed on the field using portable instruments. In the lab other parameters were considered. To preserve heavy metals in the digested samples, 3 ml of concentrated nitric acid was added to each of the samples. For additional analysis, the samples were put into a cool place with a temperature of 4°C, and EC was analyzed on the field using portable instruments. In the lab, other parameters were considered (Chakrabarty and Sarma, 2011).

2.2 Sample Testing

After the calibration, the pH of the samples was then read using the portable pH meter. For stability, the samples were put in 250 ml beakers, and the readings were taken thrice for every sample. Due to the nature of atmospheric conditions on the samples, this was quantified in real time. Employing a conductivity probe for converting some conductivity readings into TDS values, TDS was determined in the water samples. Sample water was introduced into the meter in one milliliter; simultaneously with that, on the screen there appeared the readings. The Senso Direct 150 by LOVIBOND instrument was used during the analysis. Towards the determination of the samples' total hardness, titration against EDTA as well as EBT indicators was employed. The flowing samples were prepared in a burette, diluted with distilled water, and later titrated with EDTA. To assess the mean value three readings were taken. The number of samples was changed and this method proceeded to samples. The chlorination process is used by all the filtration plants to eliminate bacteria. A measuring cylinder, burette, Erlenmeyer flask, funnel, and $AgNO_3$ solution with potassium dichromate indicator were the equipment used in the chloride test. A LOVIBOND company meter was employed to read the samples for the determination of the EC. The electrode was immersed in a 250 ml beaker containing 200 ml sample, and the reading was taken on the screen. The UV visible spectrometric method was applied to the detection of sulfates in the samples. A sample of the quantity to be analyzed was prepared where 25 milliliters were taken in a flask. After the addition of 2 ml of sulfate buffer, mix well. Mortar and Pestle were used to fully mix the solution by adding 0.5g of Barium Chloride and allowed to stand for 1 hour. Subsequently, the solution was analyzed using a spectrometer of 420 nm wavelength. Atomic absorption spectroscopy is considered the best, as well as the most effective technique used in determining heavy metals in water. In this work, we employed the Perkin Elmer Atomic Absorption Model AA-7000 to analyze Cd, Pb, Fe, Mn, Ni, Cr, and Zn.

2.3 HPI Assessment

To facilitate the understanding of the results, HPI mathematical models are used in the paper. The Heavy Metal Pollution Index (HPI) is a method of rating the impact of definite individual heavy metals upon the total water quality. This technique was used to estimate the sources in the samples (Sheykhi and Moore, 2012). The calculation of HPI follows through the given equation (1) below:

$$HPI = \frac{\sum_{i=1}^{i=n}(Qi \times Wi)}{\sum_{i=1}^{i=n} Wi} \qquad (1)$$

Where, Wi is defined for the unit weight of the *ith* parameter, and according to equation (2), the formulation of the value is as follows Qi = *ith* parameter sub index while n depicts the total number of variables included as (Abou & Hafez, 2015).

$$Wi = \frac{K}{Si} \qquad (2)$$

The following formula provides the value of Qi, where K is the proportionality constant, which is normally set to 1, and Si is the standard value allowed for the *ith* parameter.

$$Qi = \sum_{i=1}^{i=n} \frac{|Mi - Ii|}{Si - Ii} \qquad (3)$$

The HPI calculation is based on monitored value equations where Mi is the heavy metal of the ith parameter with the optimal value of Ii and the standard value of Si in ppb (µg/l) for the ith parameter. The values of Si and Ii were obtained from the source. As mentioned earlier all obtained results are in part per billion format for the HPI calculation (Nazari.,2014).

3. Results

The samples tested for the various parameters suggest that the physical parameters are mostly suitable according to the standards suggested by PAK-EPA and WHO. The results indicated for pH show a range of min value obtained as 7.0 and max value obtained as 8.4, with mean average pH of 7.6 shown in table (1), for the concentration of total dissolved solids, the result indicates that most the samples lies within the prescribed range limit by both. The min value obtained for TDS is 308 mg/l and max value obtained is 615 mg/l, with mean average TDS of 433 mg/l in table (1), for the concentration of EC, the min value obtained is 392 µS/cm and max value obtained is 682 µS/cm, with an average EC of 539 µS/cm. The concentration for sample TIR-6 and TIR-9 was above the tolerated limits, recommending unsuitable filtration plant. The graphical representation of this table is shown in Figure 2 and Figure 3 are the IDW Maps of pH, TDS and EC indicating the high and low values of the physical parameters in the study area.

Table 1: Result outcomes for the physical parameters studied for each sample.

Physical Parameters			
		Concentration (mg/l)	Concentration (µS/cm)
Sample ID	**pH**	**TDS**	**EC**
TIR-1	7.2	381	525
TIR-2	7.4	543	478
TIR-3	7.2	325	571
TIR-4	7.0	308	397
TIR-5	7.6	430	531
TIR-6	8.2	522	777
TIR-7	7.8	458	392
TIR-8	8.3	390	438
TIR-9	8.4	615	682
TIR-10	7.5	358	596
PAK- EPA Limits	6.5-8.5	100-500	1000
WHO Limits	6.5-9.5	100-500	600

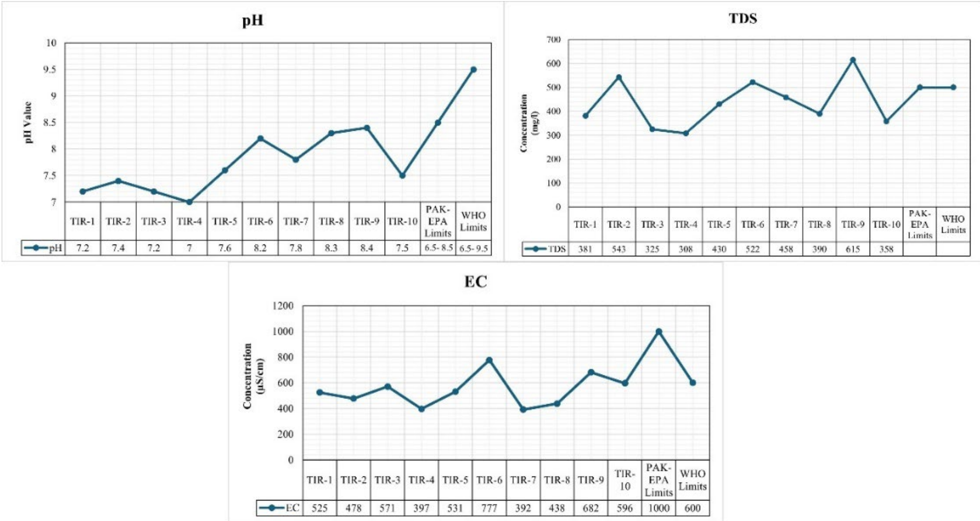


Figure 2: Graphical representation of the result outcomes for the physical parameters studied for each sample.

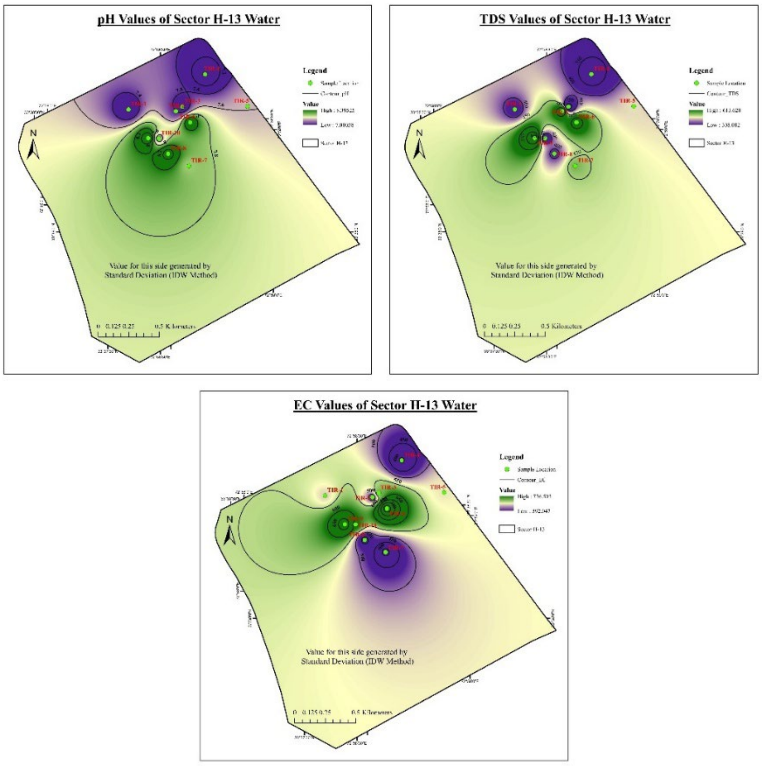
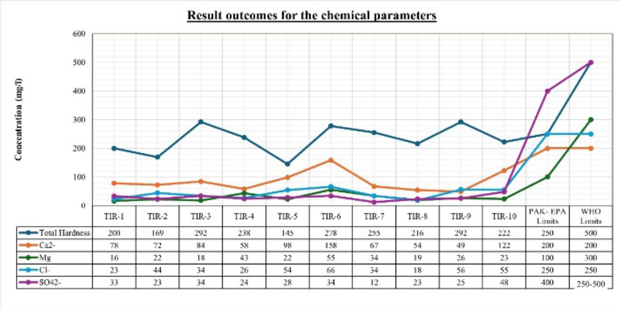


Figure 3: IDW Maps of the study area showing the result outcomes of the physical parameters.

The samples tested for the various parameters, suggest that the chemical parameters are mostly suitable according to the standards suggested by PAK-EPA and WHO except few filtration plants. The results obtained for total hardness indicates min value of 145 mg/l, and max value of 292 mg/l, with mean average total hardness of 231 mg/l table (2), which shows good indicator as an average, but sample TIR-4 shows high hardness value, while TIR-6 and TIR-9 are above the prescribed limit set by both PAK-EPA and WHO. The results obtained for Ca^{2-} ions indicates min value of 49 mg/l and max value of 158 mg/l, with mean average Ca^{2-} ions concentration of 84 mg/l table (2), which is also the good indicator. For Mg ions concentration the min value is 16 mg/l and max value is 55 mg/l, with an average Mg concentration of 27.8 mg/l table (2). For Cl^- ions, the min value is 18, with max value of 66, and average value for Cl^- concentration of 36 mg/l table (2). For SO_4^{2-} ions the min value is 12 mg/l and max value is 48 mg/l, with average SO_4^{2-} concentration of 28.4 mg/l table (2). The result shows that except total hardness in few filtration plants are all in the range prescribed by the standard limit of both agencies. So the suitability for drinking water is good, except TIR-6 and TIR-9. The graphical representation of this table is shown in Fig. 4 and Fig. 6 are the IDW Maps of chemical parameters indicating their high and low concentrations in the study area. The piper analysis was also conducted for the available chemical parameters i.e. Ca^{2-}, Mg, Cl^- and SO_4^{2-}.

Table 2: Result outcomes for the chemical parameters studied for each sample.

Chemical Parameters					
Concentration (mg/l)					
Sample ID	**Total Hardness**	**Ca^{2-}**	**Mg**	**Cl^-**	**SO_4^{2-}**
TIR-1	200	78	16	23	33
TIR-2	169	72	22	44	23
TIR-3	292	84	18	34	34
TIR-4	238	58	43	26	24
TIR-5	145	98	22	54	28
TIR-6	278	158	55	66	34
TIR-7	255	67	34	34	12
TIR-8	216	54	19	18	23
TIR-9	292	49	26	56	25
TIR-10	222	122	23	55	48
PAK- EPA Limits	250	200	100	250	400
WHO Limits	500	200	300	250	250-500



	TIR-1	TIR-2	TIR-3	TIR-4	TIR-5	TIR-6	TIR-7	TIR-8	TIR-9	TIR-10	PAK- EPA Limits	WHO Limits
Total Hardness	200	169	292	238	145	278	255	216	292	222	250	500
Ca2-	78	72	84	58	98	158	67	54	49	122	200	200
Mg	16	22	18	43	22	55	34	19	26	23	100	300
Cl-	23	44	34	26	54	66	34	18	56	55	250	250
SO42-	33	23	34	24	28	34	12	23	25	48	400	250-500

Figure 4: Graphical representation of the Result outcomes for the chemical parameters studied for each sample.

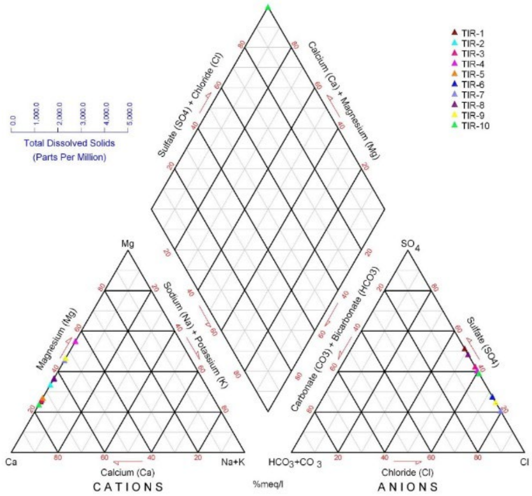


Figure 5: Piper Analysis for the distribution of anions and cations.

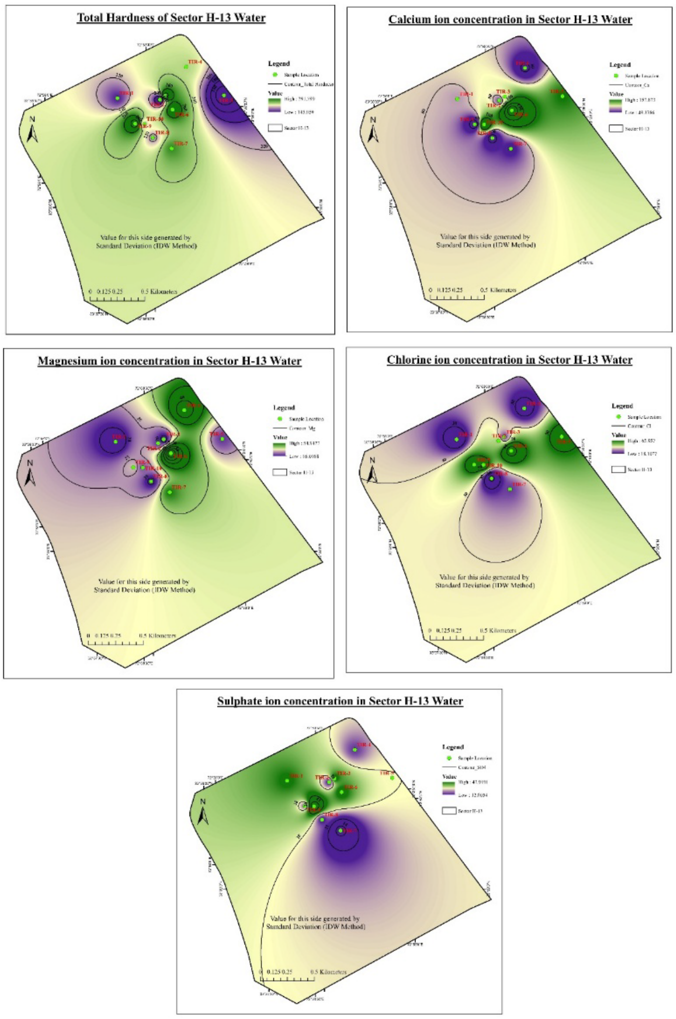


Figure 6: IDW Maps of the study area showing the result outcomes of the chemical parameters.

The concentration of Cd table (3) varies from non-detectable in samples TIR-5, TIR-8, and TIR-10, to a maximum of 0.04 mg/l in TIR-6. While all samples remain within the WHO stringent limit of 0.05 mg/l, only TIR-6 reaches and slightly surpasses the Pak-EPA limit of 0.01 mg/l. The elevated levels in TIR-6 could be attributed to industrial or agricultural runoff in the sector. Iron levels range from a low of 0.01 mg/L in TIR-10 to a high of 0.2 mg/l in TIR-6, all well within the Pak-EPA and WHO limit of 0.3 mg/l. These values suggest that the water in this area is generally safe from iron contamination, which may otherwise affect taste and color. The variation may reflect natural mineral leaching from local geology, particularly in more iron-rich rocks. The high Fe concentration in TIR-6 could be due to regional geological composition or specific soil interactions. Lead concentrations across samples mostly fall under the WHO and Pak-EPA limit of 0.01 mg/l, with notable exceptions in TIR-4, TIR-5, TIR-6, and TIR-9 table (3). The highest recorded value, 0.05 mg/l in TIR-6, is significantly above the acceptable limits, posing potential health risks due to lead's toxicity, especially affecting cognitive development in children. These elevated levels may stem from aging plumbing infrastructure, industrial discharge, or vehicular emissions, as lead can leach into water from pipes or be present in nearby soils and sediments. Nickel concentrations range from 0.001 mg/l in TIR-2 to a high of 0.1 mg/l in TIR-6 table (3). While most values stay within the WHO limit of 0.07 mg/l, the TIR-6 sample exceeds both the WHO and Pak-EPA limits. Nickel contamination may come from industrial sources. Chromium levels vary between non-detectable and 0.07 mg/l, with most values below the Pak-EPA and WHO limit of 0.05 mg/l. Samples such as TIR-6 and TIR-9 surpass this threshold table (3), which could indicate industrial pollution, as chromium is commonly used in metal plating, leather tanning, and dye production. High levels of Cr in drinking water can pose severe health risks due to its toxic and carcinogenic nature. Manganese levels are within safe limits in most samples, except for TIR-6 and TIR-9, where levels reach up to 0.5 mg/l and 0.8 mg/l, respectively table (3). These values surpass both WHO and Pak-EPA limits, indicating potential contamination from industrial effluents or natural leaching from manganese-rich minerals. Manganese, while an essential nutrient, can cause neurological issues in higher concentrations. Zinc concentrations are well below the permissible limit of 3 mg/L in WHO guidelines, with the highest concentration observed in TIR-6 at 0.7 mg/l table (3). Zinc is essential for health but can impart an undesirable taste to water in higher amounts. The elevated Zn in TIR-6 could stem from industrial sources. The graphical representation of this table is shown in Figure 7 and Fig. 8 are the IDW Maps of the heavy metal parameters indicating their high and low concentrations in the study area.

Table 3: Result outcomes for the heavy metals parameters studied for each sample.

Heavy Metals Parameters							
Concentration (mg/l)							
Sample ID	**Cd**	**Fe**	**Pb**	**Ni**	**Cr**	**Mn**	**Zn**
TIR-1	0.005	0.10	0.002	0.003	0.01	0.023	0.018
TIR-2	0.004	0.09	0.003	0.001	0.02	0,012	0.016
TIR-3	0.006	0.11	0.001	0.004	0.015	0.027	0.112
TIR-4	0.004	0.12	0.006	0.008	0.013	0.104	0.019
TIR-5	0	0.08	0.009	0.009	0	0	0.213
TIR-6	0.04	0.2	0.05	0.100	0.06	0.500	0.7
TIR-7	0.01	0.09	0.008	0.001	0.0016	0.019	0.011
TIR-8	0	0.10	0.001	0.006	0	0.013	0.008
TIR-9	0.01	0.1	0.02	0.011	0.07	0.8	0.09
TIR-10	0	0.01	0.004	0.004	0.011	0.008	0.38
PAK- EPA Limits	0.01	0.3	0.010	0.020	0.050	0.500	5
WHO Limits	0.05	0.3	0.01	0.07	0.05	0.4	3

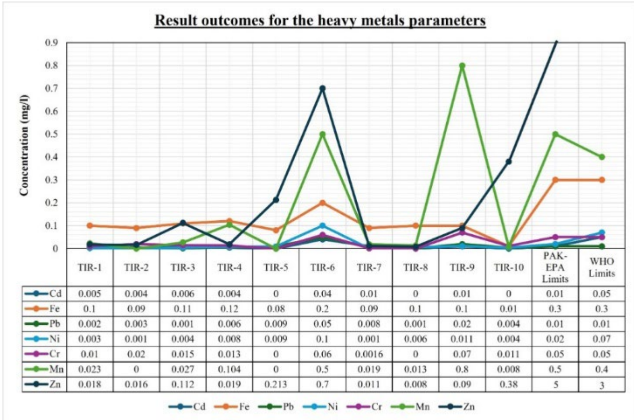


Figure 7: Graphical representation of the result outcomes for the heavy metals parameters studied for each sample.

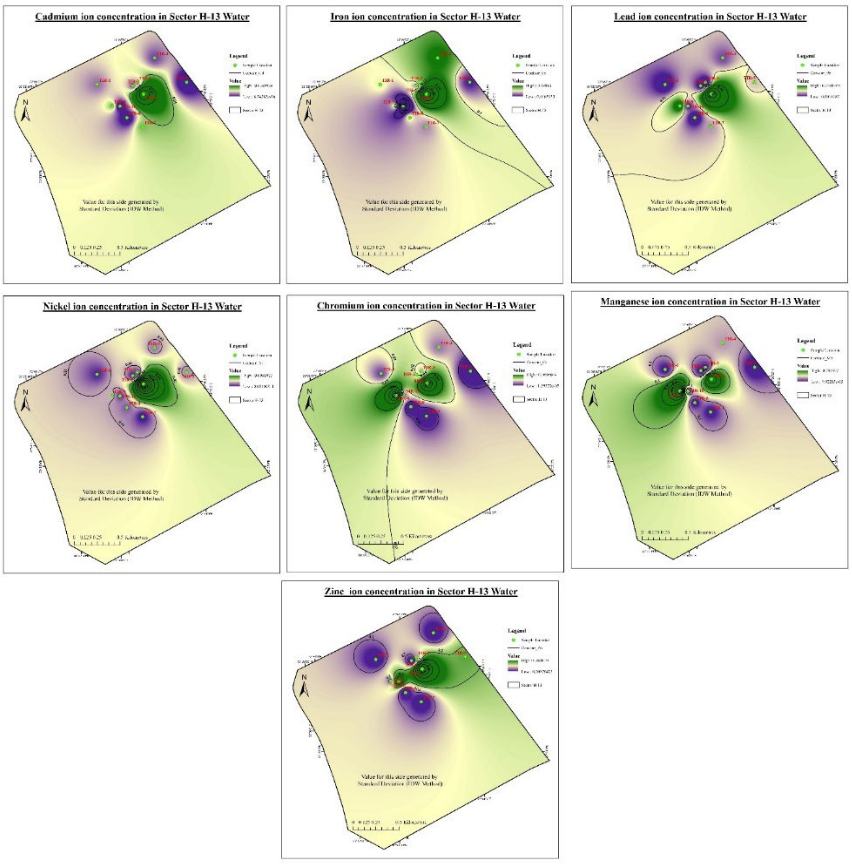


Figure 8: IDW Maps of the result outcomes for the heavy metals parameters.

4. Discussion

The physical parameters of the water samples collected from Sector H-13, Islamabad, reveal insights into pH, total dissolved solids (TDS), and electrical conductivity (EC) across ten locations. The pH values range from 7.0 to 8.4, comfortably within the permissible limits set by both the Pakistan Environmental Protection Agency (Pak-EPA) and WHO guidelines, indicating neutral to slightly alkaline conditions. TDS levels vary between 308 and 615 mg/l, with samples TIR-2, TIR-6, and TIR-9 exceeding the recommended threshold of 500 mg/l per WHO standards, suggesting potential mineral dissolution or contamination. EC measurements are within safe levels across all samples except TIR-6 and TIR-9, which approach or slightly exceed the WHO threshold of 600 µS/cm. These elevated TDS and EC values in TIR-6 and TIR-9 indicate a higher concentration of ions, possibly linked to anthropogenic or geological factors.

The chemical analysis of water samples from sector highlights variations in total hardness, calcium (Ca^{2+}), magnesium (Mg), chloride (Cl^{-}), and sulfate (SO_4^{2-}) concentrations. Total hardness values range from 145 to 292 mg/L, with all samples within the Pak-EPA limit of 250 mg/l, though TIR-3, TIR-6, and TIR-9 show higher hardness levels. Calcium and magnesium concentrations are also well within permissible levels, suggesting balanced mineral content with no excessive hardness contributors. Chloride levels, between 18 and 66 mg/l, fall far below the maximum allowable concentrations, indicating limited chloride-based contamination sources. Sulfate concentrations are similarly low, ranging from 12 to 48 mg/l, comfortably below WHO lower threshold, indicating minimal industrial or agricultural influence. Overall, the results show that the water chemistry meets both national and international standards for safe drinking water, with some elevated hardness in certain samples possibly linked to geological factors rather than contamination.

Sample TIR-6 consistently exhibits the highest concentrations across several heavy metals, including Cd, Fe, Pb, Ni, Cr, Mn, and Zn, indicating a possible contamination hotspot. This pattern suggests potential localized pollution sources, perhaps an industrial site or runoff from agricultural activities using metal-based fertilizers. The general compliance with WHO and Pak-EPA guidelines in other samples suggests that water quality is mostly safe, though areas with specific industrial activities or infrastructure issues may still present localized risks. Elevated levels of lead, chromium, and nickel in samples like TIR-4, TIR-5, TIR-9, and TIR-6 highlight the need for targeted remediation and monitoring, as prolonged exposure to these contaminants can lead to significant health issues.

4.1 HPI Evaluation

Majority of the samples have Low HPI values and therefore all samples poses little danger in so far as the concentration of the heavy metals in these samples is concerned. The results of the tested samples TIR-6 are higher than the safe level and TIR-9 has higher contamination for certain type of metal. This analysis shows the possibility of pollution source within these areas, in limited geographical extent. The HPI evaluation was conducted using the same index formula to calculate the values of each metals and result was compiled using python coding, shown below;

4.2 Coding for calculating HPI

```
# Redefining the data and recalculating HPI after environment reset import pandas as pd

# Define the data for heavy metal concentrations in each sample

data = {

  "Sample ID": ["TIR-1", "TIR-2", "TIR-3", "TIR-4", "TIR-5", "TIR-6", "TIR-7", "TIR-8","TIR-9", "TIR-10"],

  "Cd (mg/l)": [0.005, 0.004, 0.006, 0.004, 0, 0.04, 0.01, 0, 0.01, 0],

  "Fe (mg/l)": [0.1, 0.09, 0.11, 0.12, 0.08, 0.2, 0.09, 0.1, 0.1, 0.01],

  "Pb (mg/l)": [0.002, 0.003, 0.001, 0.006, 0.009, 0.05, 0.008, 0.001, 0.02, 0.004],

  "Ni (mg/l)": [0.003, 0.001, 0.004, 0.008, 0.009, 0.1, 0.001, 0.006, 0.011, 0.004],

  "Cr (mg/l)": [0.01, 0.02, 0.015, 0.013, 0, 0.06, 0.0016, 0, 0.07, 0.011],

  "Mn (mg/l)": [0.023, 0.012, 0.027, 0.104, 0, 0.5, 0.019, 0.013, 0.8, 0.008],

  "Zn (mg/l)": [0.018, 0.016, 0.112, 0.019, 0.213, 0.7, 0.011, 0.008, 0.09, 0.38]

# Define permissible limits set by PAK-EPA for each metal

epa_limits = {

  "Cd": 0.01, "Fe": 0.3, "Pb": 0.01, "Ni": 0.02, "Cr": 0.05, "Mn": 0.5, "Zn": 5

# Calculate weightage Wi for each metal

weights = {metal: 1 / limit for metal, limit in epa_limits.items()

# Convert data to a DataFrame for easy manipulation

df = pd.DataFrame(data)

# Calculate Qi (Sub-index) for each sample and metal

for metal, limit in epa_limits.items():

  df[f"Q_{metal}"] = (df[f"{metal} (mg/l)"] / limit) * 100

# Calculate Qi * Wi for each sample

for metal, weight in weights.items():

  df[f"Qi_Wi_{metal}"] = df[f"Q_{metal}"] * weight

# Sum Qi*Wi and Wi for each sample to get HPI

df["HPI"] = df[[f"Qi_Wi_{metal}" for metal in epa_limits]].sum(axis=1) / sum(weights.values())

# Add remarks based on HPI values

df["Remarks"] = df["HPI"].apply(lambda x: "Safe" if x < 100 else "Unsafe")

# Select relevant columns to display

results = df[["Sample ID", "HPI", "Remarks"]]

results
```

Table 4: Result outcomes for the heavy metals pollution index for each sample.

Sample ID	Collective HPI value	Quality for drinking	Remarks
TIR-1	30.02	Safe	.
TIR-2	29.60	Safe	
TIR-3	31.70	Safe	
TIR-4	46.07	Safe	
TIR-5	41.16	Safe	
TIR-6	427.63	Unsafe	Cd, Fe and Mn with the above limit HPI is the highest contributor.
TIR-7	66.86	Safe	
TIR-8	9.50	Safe	
TIR-9	130.59	Unsafe	Cd, Fe, Pb and Cr with the above limit HPI is the highest contributor.
TIR-10	19.80	Safe	

The graphical representation of the collective HPI value is shown in Figure 9 and Figure 10 is its IDW Map indicating its high and low value in the study area.

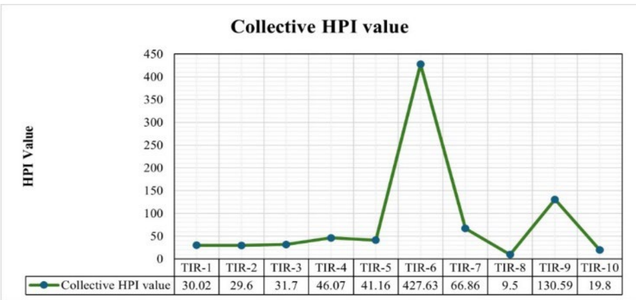


Figure 9: Graphical representation of the collective HPI value of the study area.

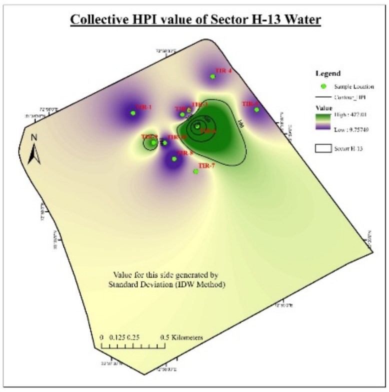


Figure 10: IDW Map of the collective HPI value of the study area

5. Conclusion

The comprehensive analysis of drinking water samples from Sector H-13, Islamabad, reveals that, while most samples are within the permissible limits set by both WHO and Pak-EPA standards, a few samples (notably TIR-6 and TIR-9) show elevated concentrations of heavy metals and some physical and chemical parameters. Physical parameters such as pH, TDS, and EC are largely suitable, with only slight exceed in specific samples. Chemical parameters also mostly align with regulatory limits, though total hardness in certain samples suggests the presence of mineral deposits possibly of geological origin.

The enhanced levels of Cd, Pb, Ni, Cr, Mn and Zn in samples TIR-6 and TIR-9 indicate localized pollution from industrial effluent or from the usage of metallic agricultural inputs or from near infrastructure. The HPI assessment reveals that although the majority of the samples have low risk, the high HPI of TIR-6 and TIR-9 require the focus of the health hazards to be prioritized and addressed. Hence, combining the results that show that currently the water quality in the Sector H-13 is fairly safe the positive contamination hot spots should underline the necessity of continuous water quality assessment and control measures in order to provide the community with safe drinking water.

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