Assessment of the Water Quality Pollution Indices and the Corrosivity Analysis for Groundwater in Mubarakganj Sugar Mills Region, Kaliganj, Jhenaidah

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Outline of the Presentation

- Introduction
- Objective of the Study
- Methodology
- Results and Discussion
- Evaluation of Pollution Indices
- Corrosion Study
- Conclusion

Introduction

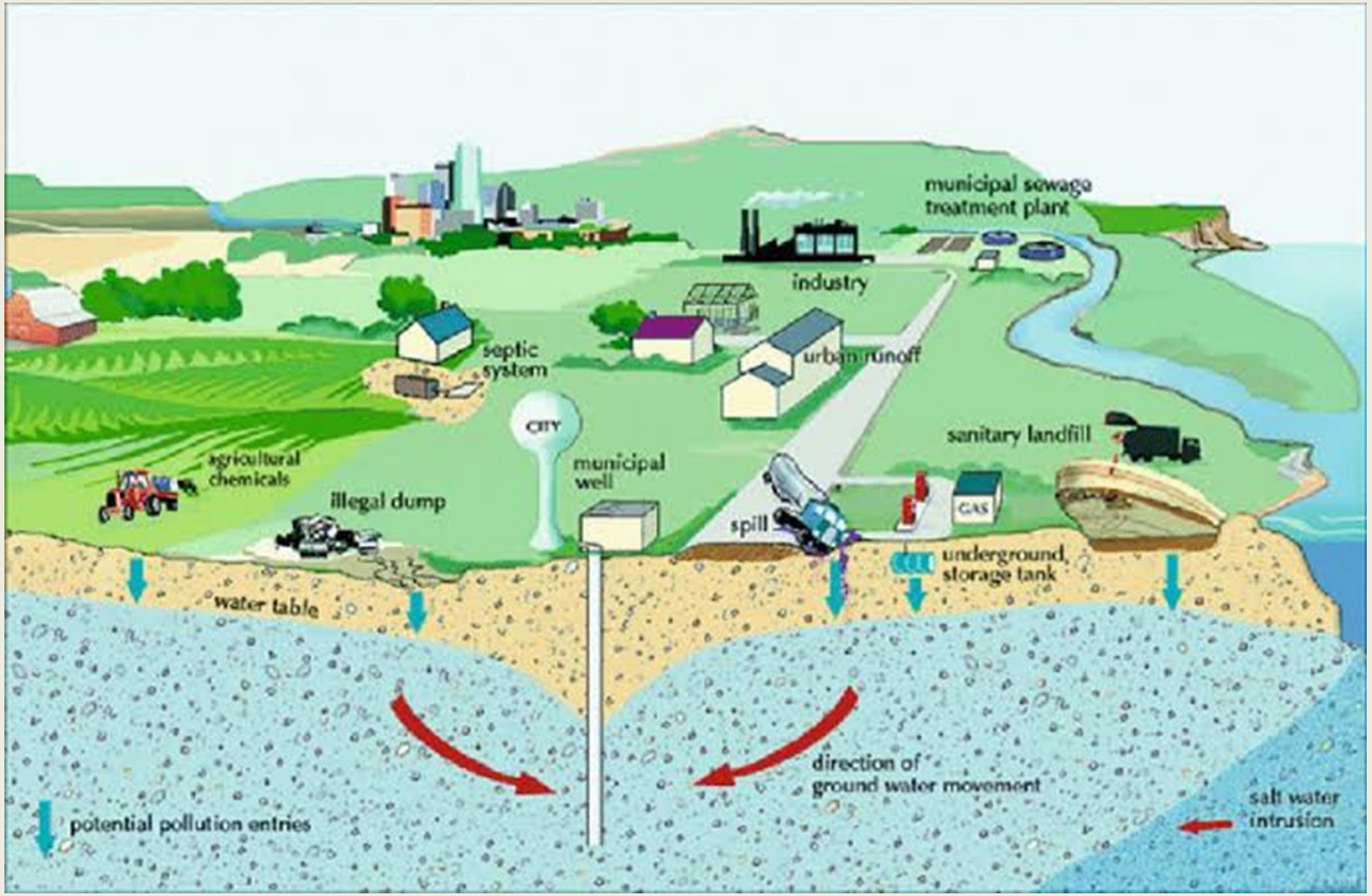


Fig 1: Groundwater pollution

- Increased Anthropogenic activities, both agricultural and industrial
- Heavy metal pollution in Ground Water (GW)
- Risk posed from GW with potentials to cause diseases like anorexia, immune dysfunction, hypertension, liver and kidney disorders, cancers etc.

Objective of the Study

- Determine the concentrations of **HEAVY METALS** in ground water as well as the effluent collected from different locations of Mubarakganj Sugar Mills region and compare the results of groundwater with standards for drinking purposes.

- Assessment of the **WATER QUALITY POLLUTION INDICES** of trace metals and identify the associated risk.

- **CORROSIVITY STUDY** of the groundwater.

Study Area

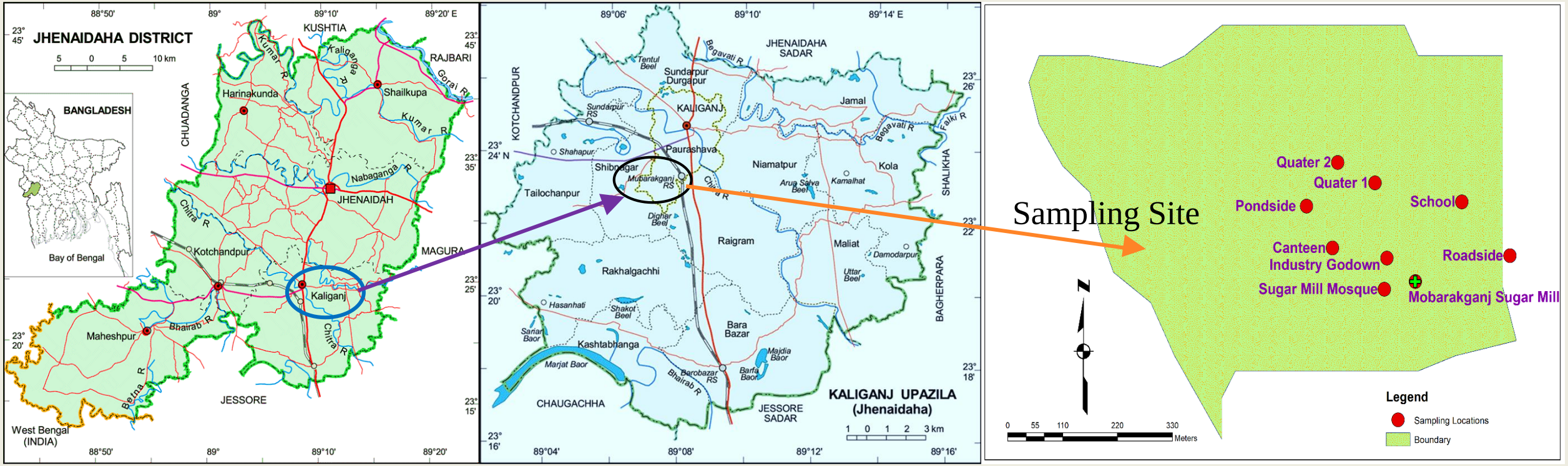


Fig 2: Study Area of Mubarakganj Sugar Mills, Kaliganj, Jhenaidaha

Mubarakganj Sugar Mill is situated in Kaliganj, Jhenaidah, sited at 23°23′ N and 89°08′ E. This sugar mill was established in 1965 and its total area is 189.9 acres and the cultivable land near mill zone is 42000 acres. Population density in Kaliganj upzilla is the highest in Jhenaidah district (BBS 2011). The sampling was done on December 2018 - January 2019.

Methodology

- **Eleven (11)** GW samples (1000 mL each) of various depth (80 -180 ft) and one **(1)** industrial effluent of Mubarakganj Sugar Mill were collected.
- pH, Electrical conductivity (EC), Salinity and Turbidity of samples were measured on sampling.
- For heavy metals and trace element analysis, acid digestion method was used. Atomic Absorption Spectrophotometer (Shimadzu AA6800) was used for heavy metals detection and UV-Visible Spectrophotometer were used for the analysis of some anions.
- For method validation, “Spike System” were used and the heavy metals recovery were found 89% to 94%.

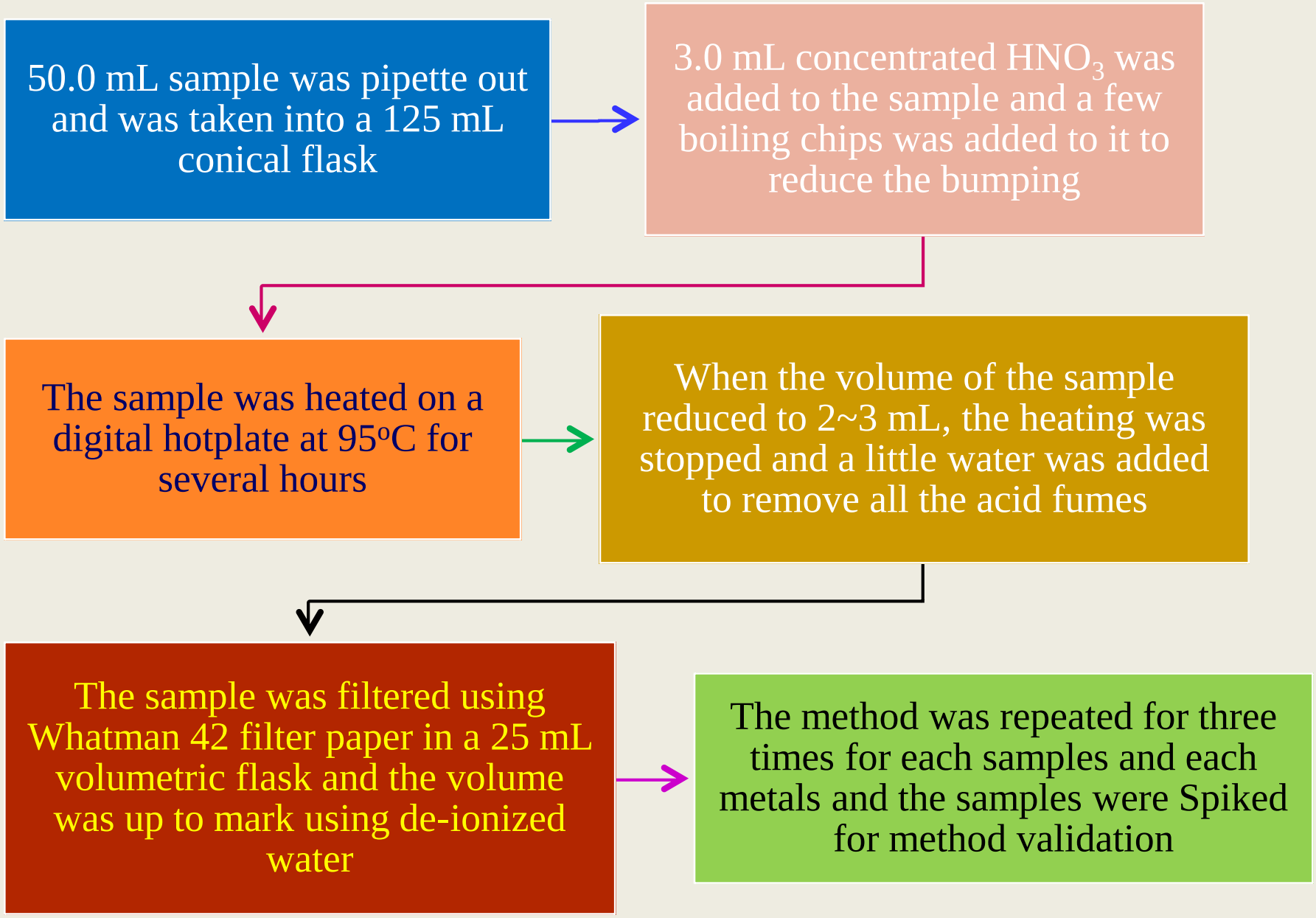


Figure 3: Acid Digestion method of ground water samples.

Results and Discussion

Table 1: Descriptive statistics of heavy metals in collected groundwater samples.

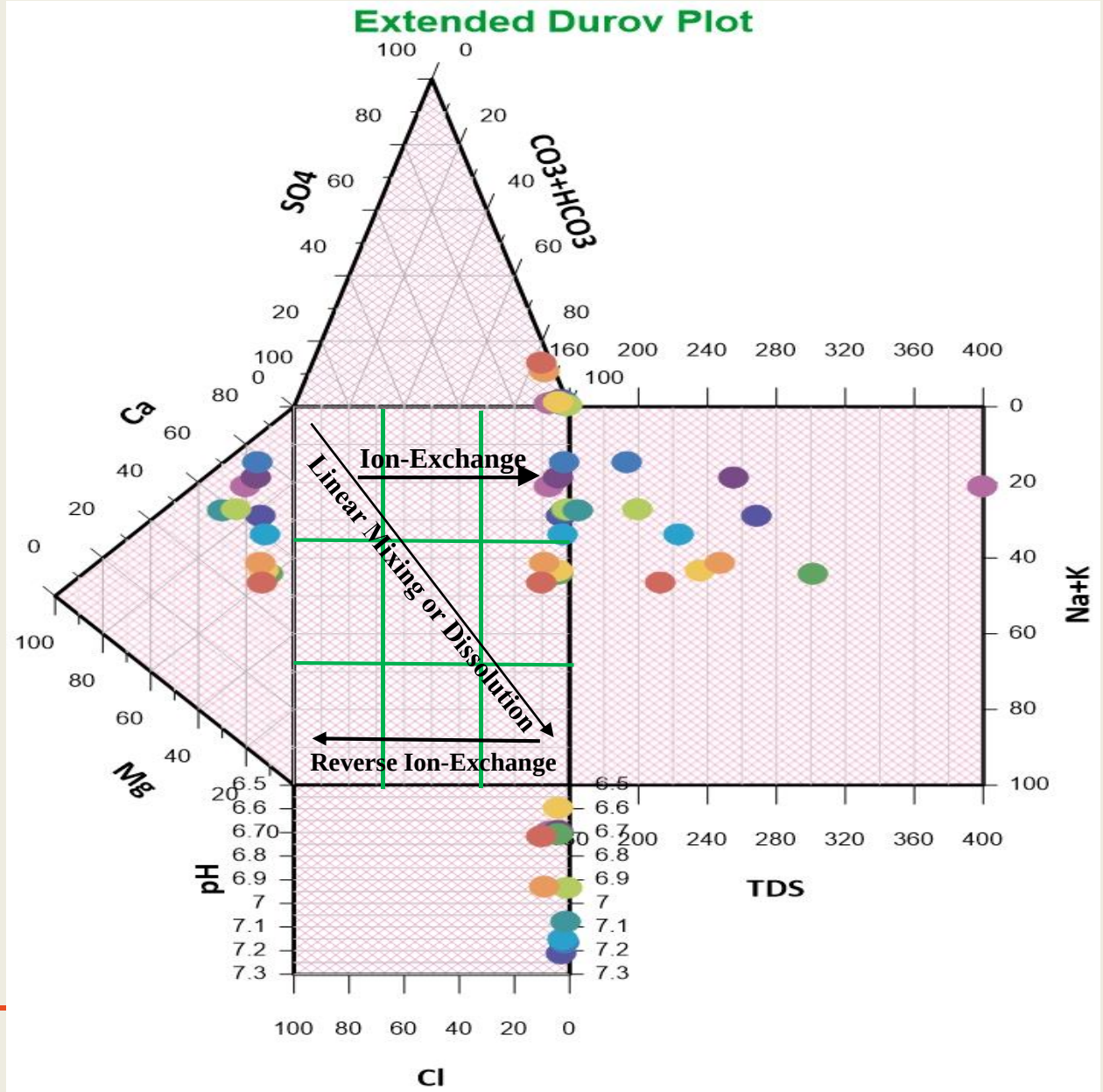
Parameters	pH	EC (µS/cm)	TDS (mg/L)	Salinity ‰	Turbidity (NTU)	HCO_3^- (mg/L)	NO_3^- (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)	Na (mg/L)	K (mg/L)
Minimum (mg/L)	6.598	299.0	164.45	0.3	**11.97**	52.000	1.299	1.030	0.760	4.950	0.520
Maximum (mg/L)	7.209	614.0	399.1	**0.6**	**104.9**	170.000	**13.112**	8.010	9.020	67.040	1.790
Average (mg/L)	6.898	429.636	245.364	0.445	54.769	102.36	7.627	3.081	2.672	25.900	1.091
Standard Deviation	---	±30.00	±10.51	---	±3.27	±4.15	±0.467	±0.694	±0.319	±1.023	±0.290
WHO (2017)	**6.5-8.5**	---	**1000.00**	**0.5**	**4**	**250**	**50**	**250**	**250**	**200**	**10**
BNDWQS (2009)	**6.5-8.5**	**2000**	**1000.00**	**<1.0**	**10**	**600**	**10**	**400**	**600**	**200**	**12**

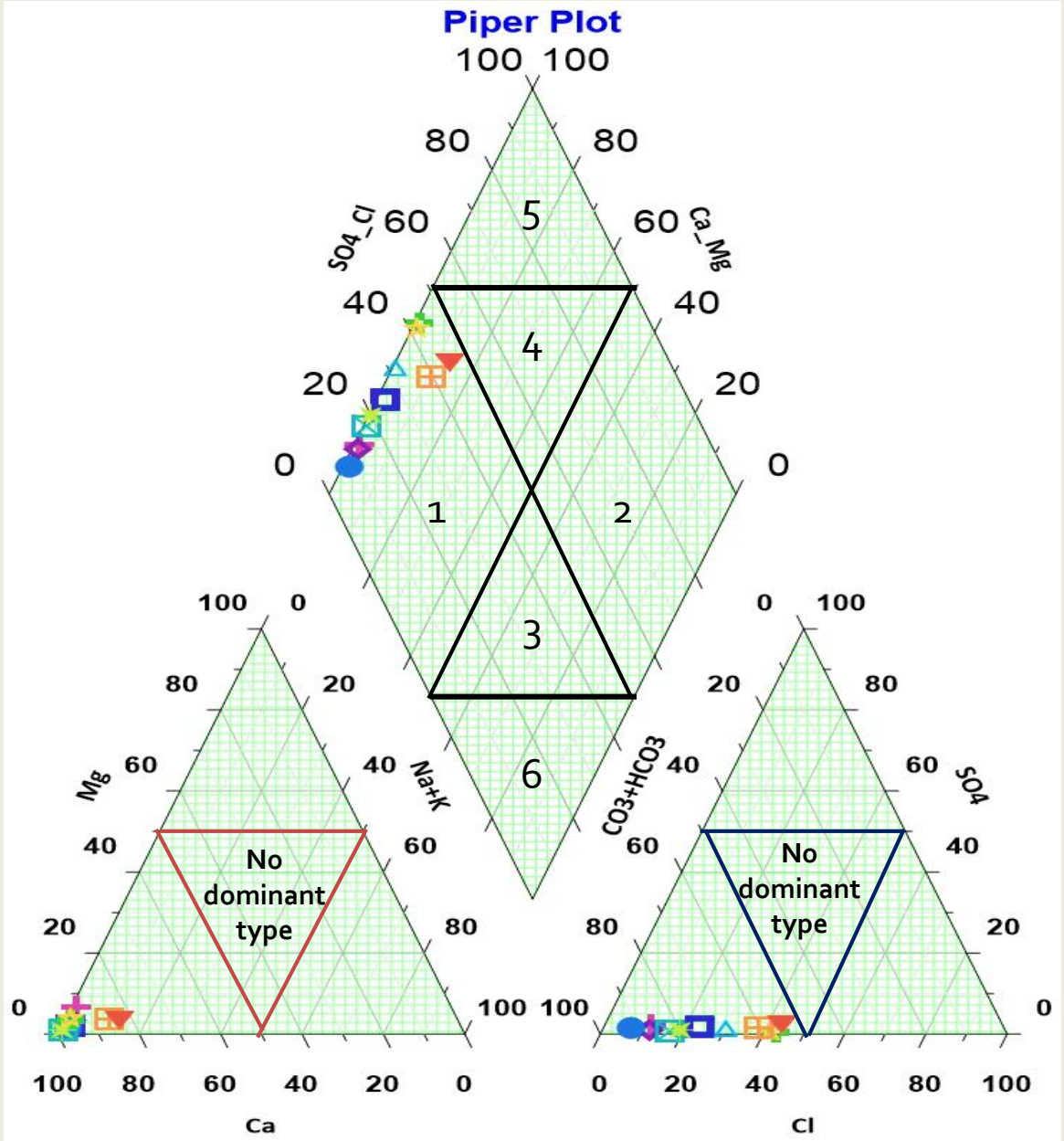
Results and Discussion

Table 1: Descriptive statistics of heavy metals in collected groundwater samples (Cont.).

Parameters	Ca (mg/L)	Mg (mg/L)	Fe (mg/L)	Zn (mg/L)	Cu (mg/L)	Al (mg/L)	Cr (mg/L)	Cd (mg/L)	Ni (mg/L)	Pb (mg/L)
Minimum (mg/L)	37.020	10.680	**0.375**	0.037	0.013	0.006	0.007	**0.006**	0.021	0.009
Maximum (mg/L)	110.610	**48.090**	**2.777**	0.174	0.064	0.015	**0.558**	**0.032**	**0.229**	**0.035**
Average (mg/L)	69.651	20.504	1.792	0.071	0.041	0.011	0.131	0.015	0.092	0.022
Standard Deviation	±6.371	±2.957	±0.165	±0.013	±0.004	±0.001	±0.046	±0.002	±0.019	±0.008
WHO (2017)	**75.0**	**50.0**	**0.30**	**5.0**	**2.0**	**0.2**	**0.05**	**0.003**	**0.07**	**0.01**
BNDWQS (2009)	**75.0**	**35.0**	**1.0**	**5.0**	**1.0**	**0.2**	**0.05**	**0.005**	**0.1**	**0.05**

Results and Discussion





Results and Discussion

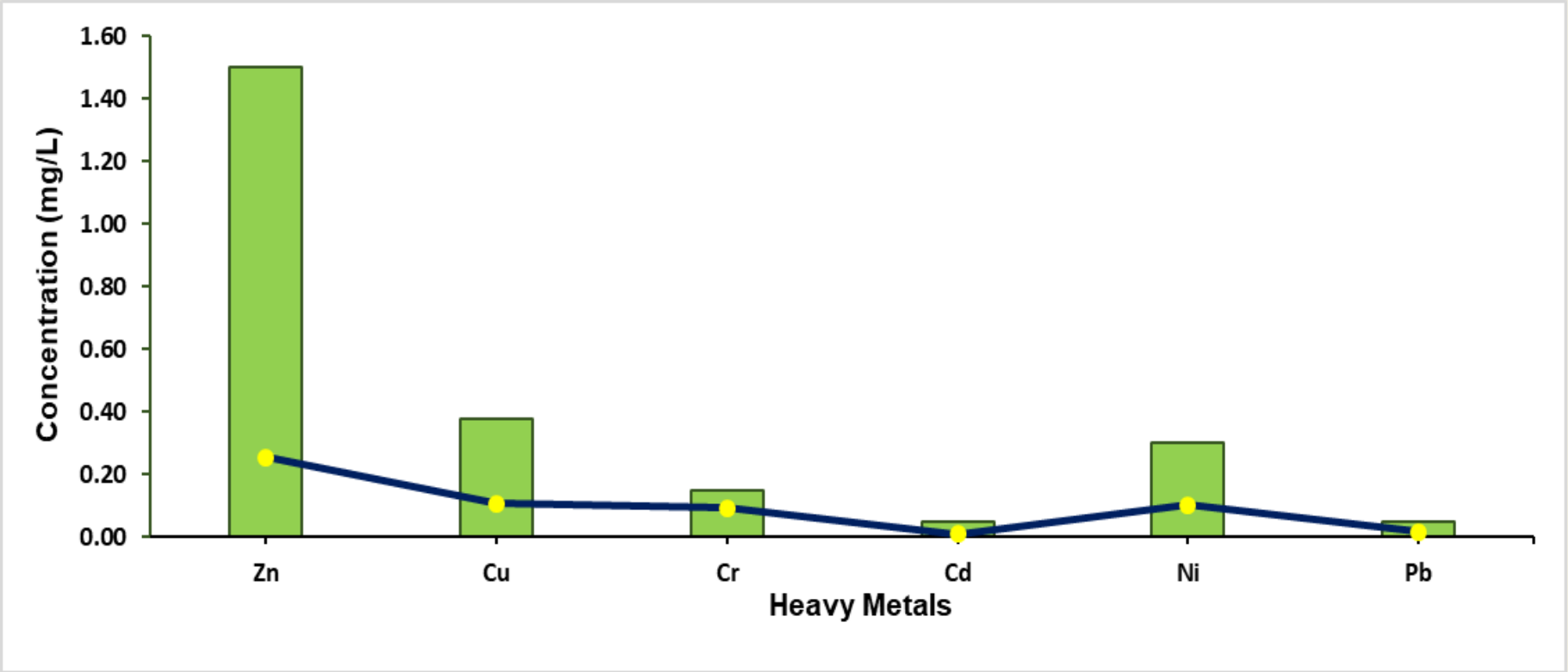


Figure 4: Concentration of some heavy metals in the effluent.

Results and Discussion

Table-2: Correlation analysis of heavy metals in the collected groundwater samples.

Variables	*Fe*	*Zn*	*Cu*	*Al*	*Cr*	*Cd*	*Ni*	*Pb*
Fe	1.0000							
Zn	-0.0112	1.0000						
Cu	-0.3238	**0.4998**	1.0000					
Al	0.0041	**-0.8013**	-0.4611	1.0000				
Cr	0.3778	-0.3699	-0.0201	**0.5176**	1.0000			
Cd	0.1129	-0.3194	-0.0188	0.1064	0.0753	1.0000		
Ni	**0.6131**	-0.2868	0.0276	0.2992	0.4433	0.3089	1.0000	
Pb	**-0.9902**	**0.8590**	**0.9563**	0.0200	**0.6418**	**-0.5000**	**-0.5270**	1.0000

Pollution Indices

Heavy metal pollution index is a method of rating that shows the composite influence of individual heavy metal on the overall quality of water.

Table-2: Heavy metal pollution indices in the collected groundwater samples.

Indices	Equation	Classification	Samples (%)
Heavy Metal Evaluation Index (HEI)	$\mathbf{HEI = \Sigma(H_c/H_{MAC})}$	**HEI≤10:** low metal concentration in drinking water **10≤HEI≤20:** medium metal concentration in drinking water **HEI>20:** high metal concentration in drinking water	18% **64%** 18%
Heavy Metal Pollution Index (HPI)	$\mathbf{HPI= \Sigma((W_i \times Q_i)/W_i)}$ where $\mathbf{Q_i = \Sigma(((M_i - I_i) / (S_i - I_i)) \times 100)}$	**HPI<100:** low heavy metal pollution, **HPI = 100:** heavy metal pollution on the threshold risk **HPI>100:** high heavy metal pollution (critical pollution index)	**100%**
The Degree of Contamination (C_d)	$\mathbf{C_d = \Sigma Cf_i}$ Where, $\mathbf{Cf_i = (CA_i / CN_i) - 1}$	$\mathbf{C_d < 1}$: low level contamination **1<Cd<3:** medium contamination $\mathbf{C_d>3}$: high contamination	9% 9% **82%**

Pollution Indices

Table-2: Heavy metal pollution indices in the collected groundwater samples (cont.).

Indices	Equation	Classification	Samples (%)
Modified Degree of Contamination (mC_d)	$mC_d = \Sigma Cf_i / n$	**mCd<1.5:** Nil to very low degree of contamination **1.5≤mCd<2:** Low degree of contamination **2≤mCd<4:** Moderate degree of contamination **4≤mCd<8:** High degree of contamination	**82%** 9% 9%
Pollution Load Index (PLI)	$PLI = (Cf_1 \times Cf_2 \times Cf_3 \times ..... \times Cf_n)^{1/n}$	**PLI<1:** Unpolluted condition of the site **PLI = 1:** The presence of only baseline levels of pollutants **PLI>1:** Progressive deterioration of the water quality	27% **73%**
Potential Ecological Risks (PERI)	$PERI = \Sigma E_r$ Where, $E_r = T_{rf} \times CF$	**PERI<150:** Low ecological risk **150<PERI<300:** Moderate ecological risk **300<PERI<600:** Considerable ecological risk **PERI>600**: Very high ecological risk	36% **55%** 9%
Pollution Index (PI)	$PI = \sqrt{[\{(CF_{avg})^2 + (CF_{max})^2\}/2]}$	**PI<0.7:** No pollution **0.7<PI<1**: indicates slightly polluted **1.0<PI<2.0:** moderately polluted **2.0<P<3.0:** Severely polluted condition **PI>3.0:** heavily polluted condition	 **50%** 25% 25%

Pollution Indices

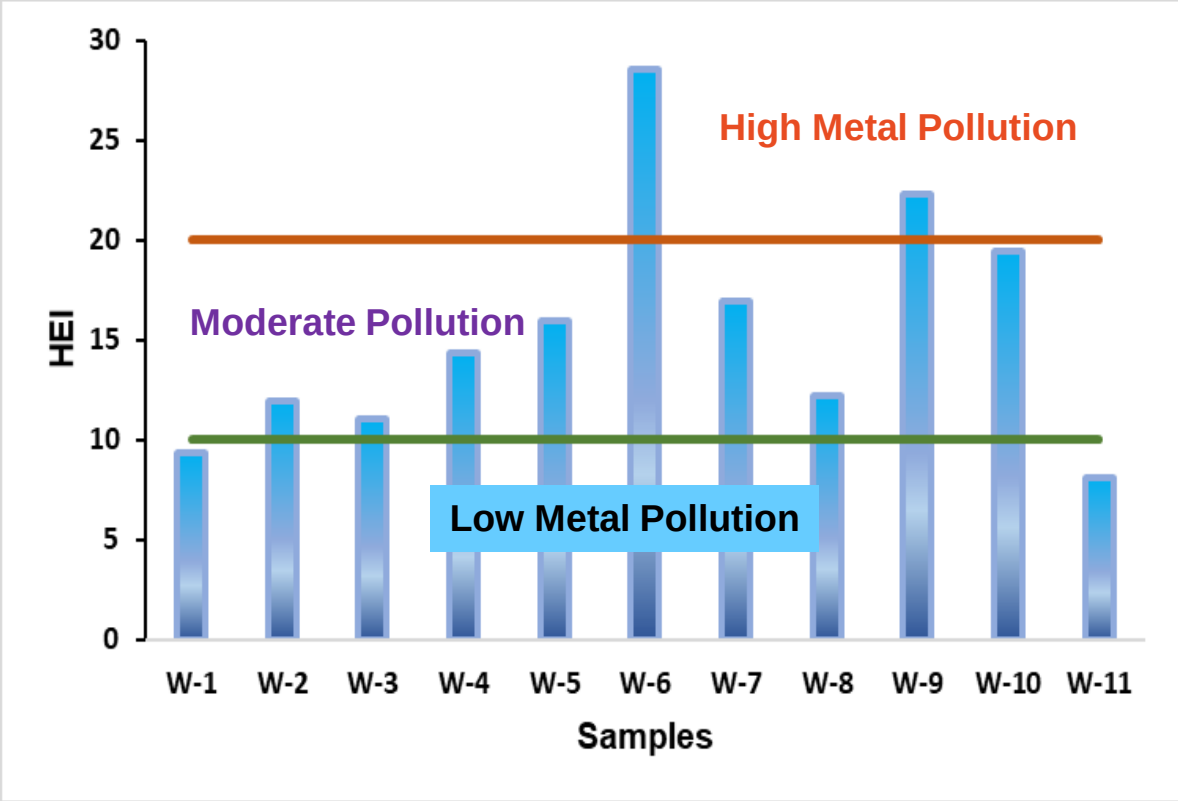


Figure 5: Graphical Representation of HEI

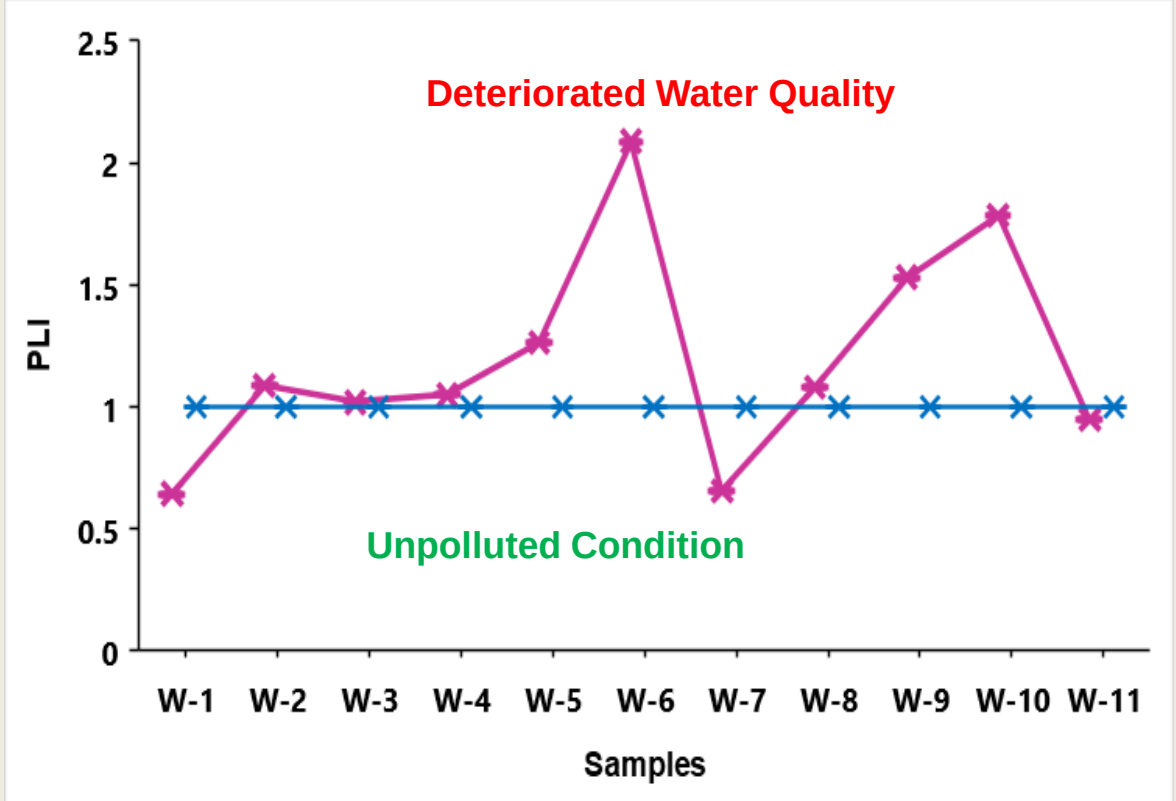


Figure 6: Graphical Distribution of PLI in Groundwater

Pollution Indices

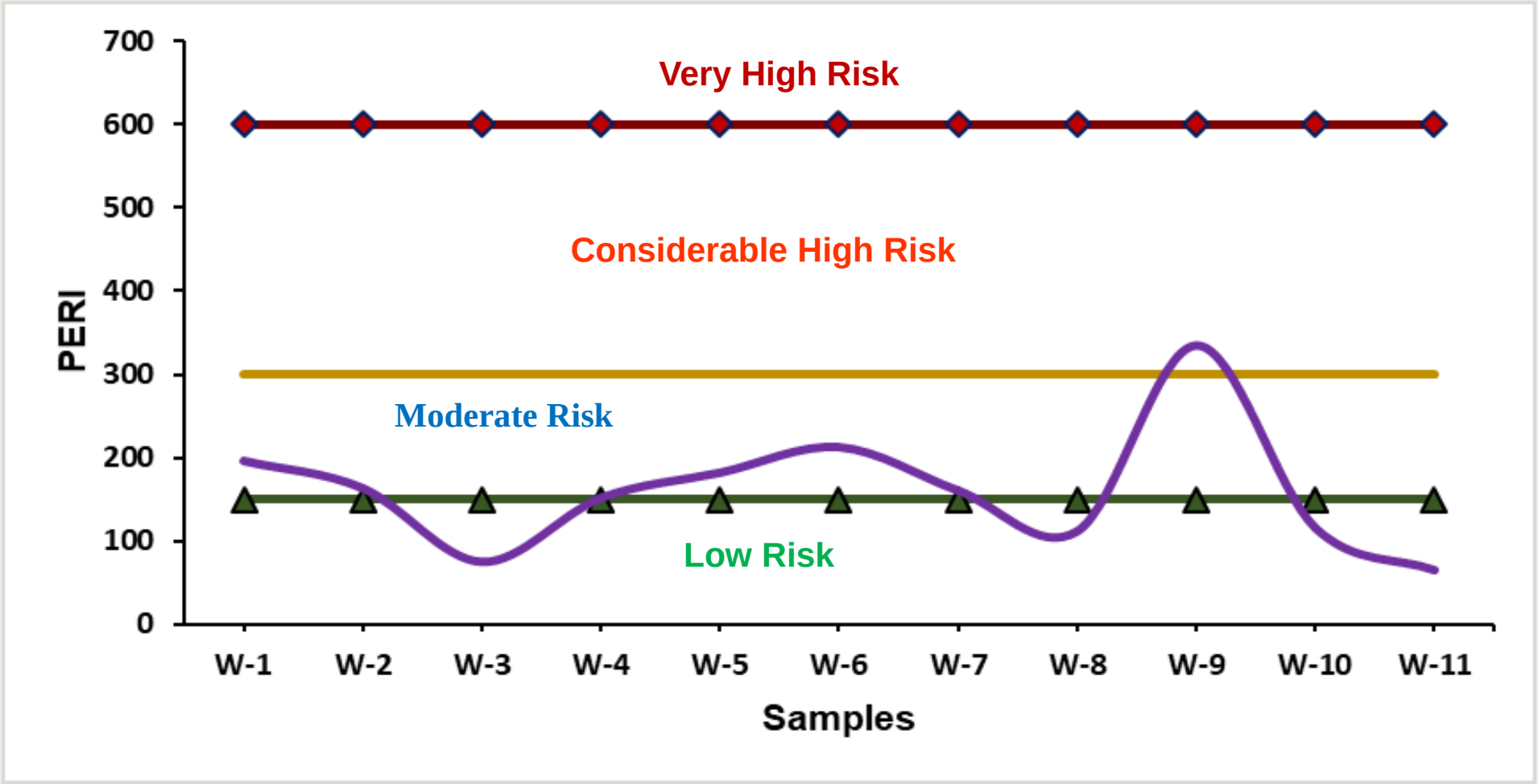
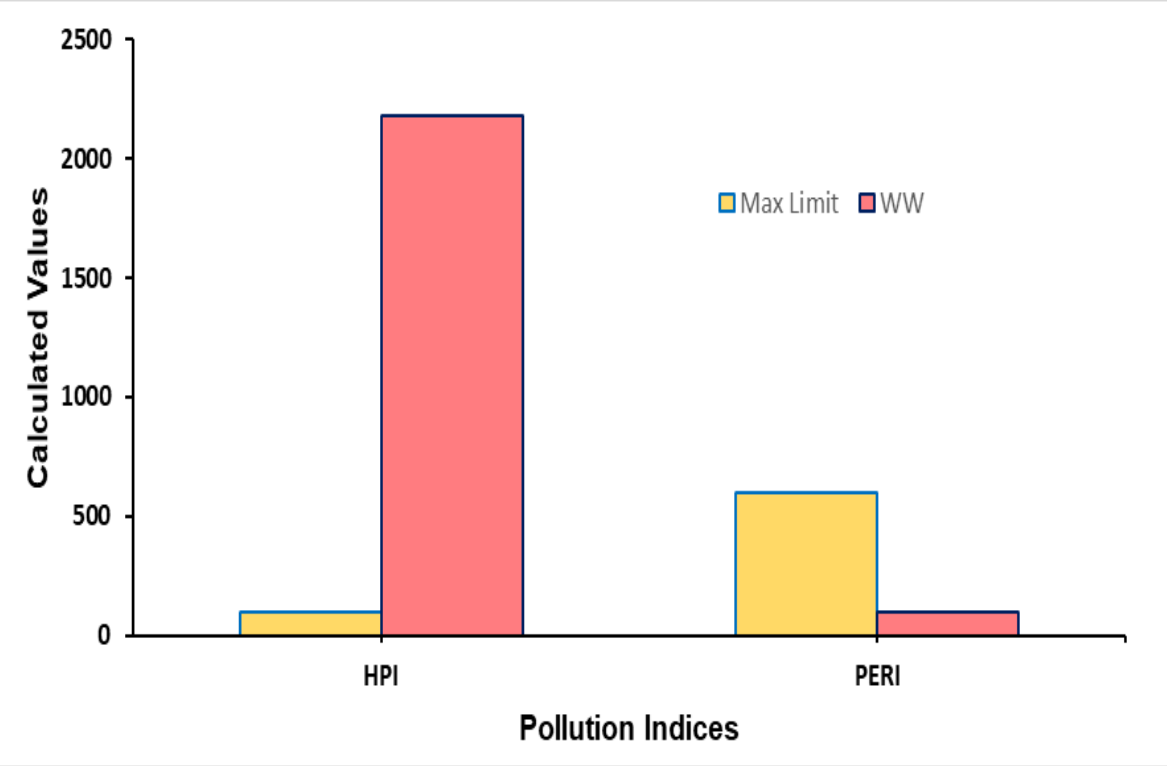


Figure 7: Graphical Distribution of PERI

Pollution Indices



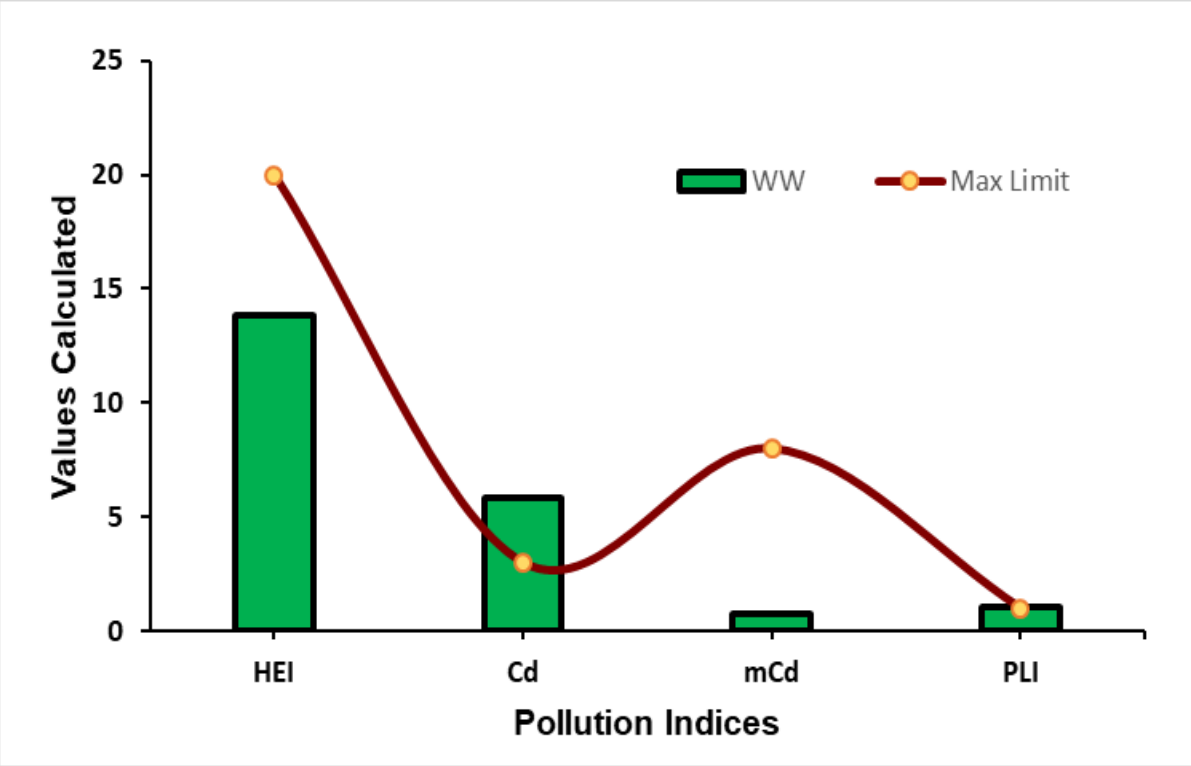


Figure 8: Pollution Indices of the Effluent of Mubarakganj Sugar Mill

Health Risk Assessment

To identify the potential health risks several parameters has been measured.

- **Hazard Quotient (HQ)**:

$$HQ_{ing} = \frac{C_{water} \times IR \times EF \times ED}{AT \times BW \times R_fD_{oral}}$$

$$HQ_{dermal} = \frac{C_{water} \times IR \times EF \times ED \times S_A \times E_T \times K_p \times CF}{AT \times BW \times R_fD_{dermal}}$$

- **Hazard Index (HI):** $HI_{ing} = \sum HQ_{ing}$ and $HI_{dermal} = \sum HQ_{dermal}$

- **Carcinogenic Risk (CR):**

$$CR_{ing} = \frac{C_{water} \times IR \times EF \times ED}{AT \times BW} \times CSF$$

Health Risk Assessment

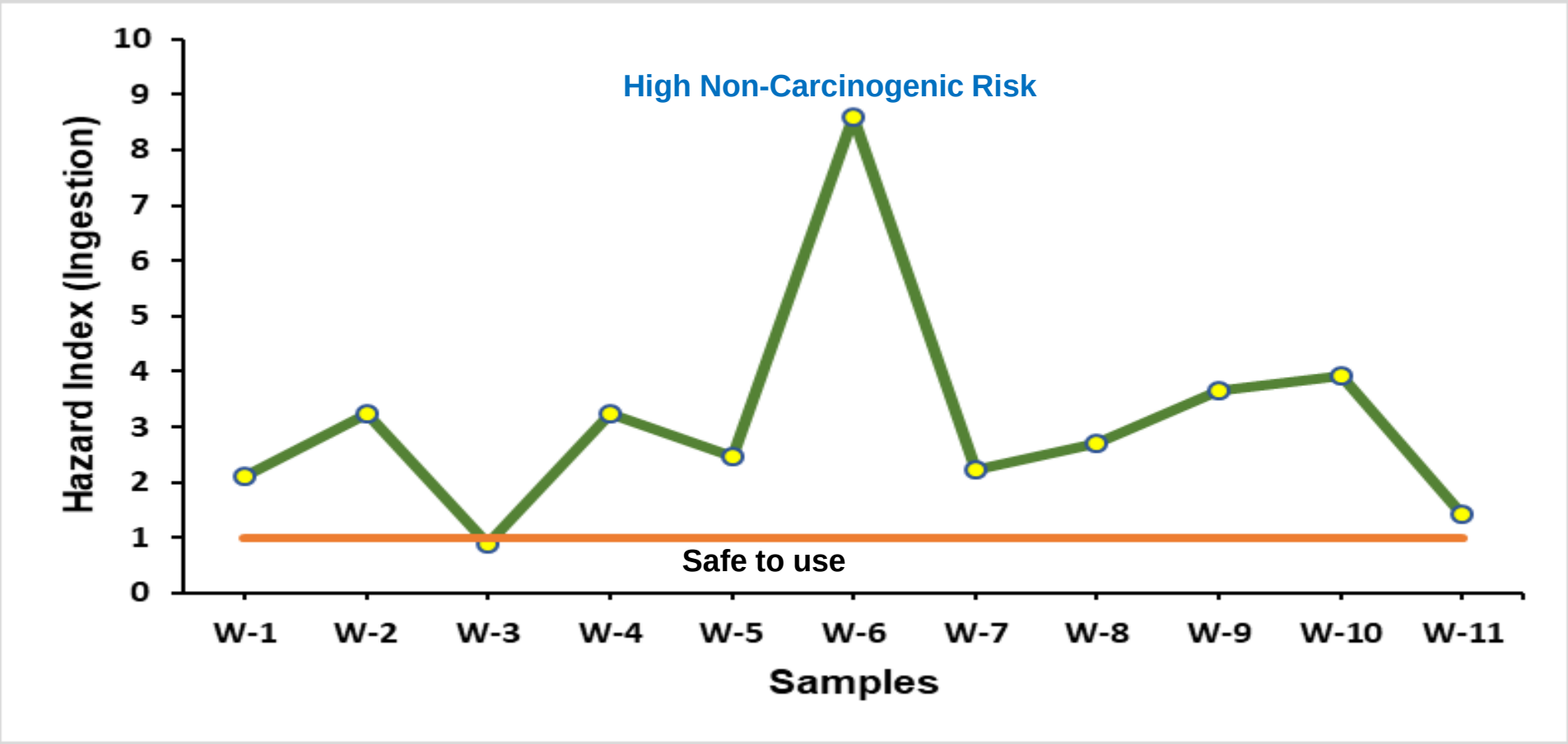
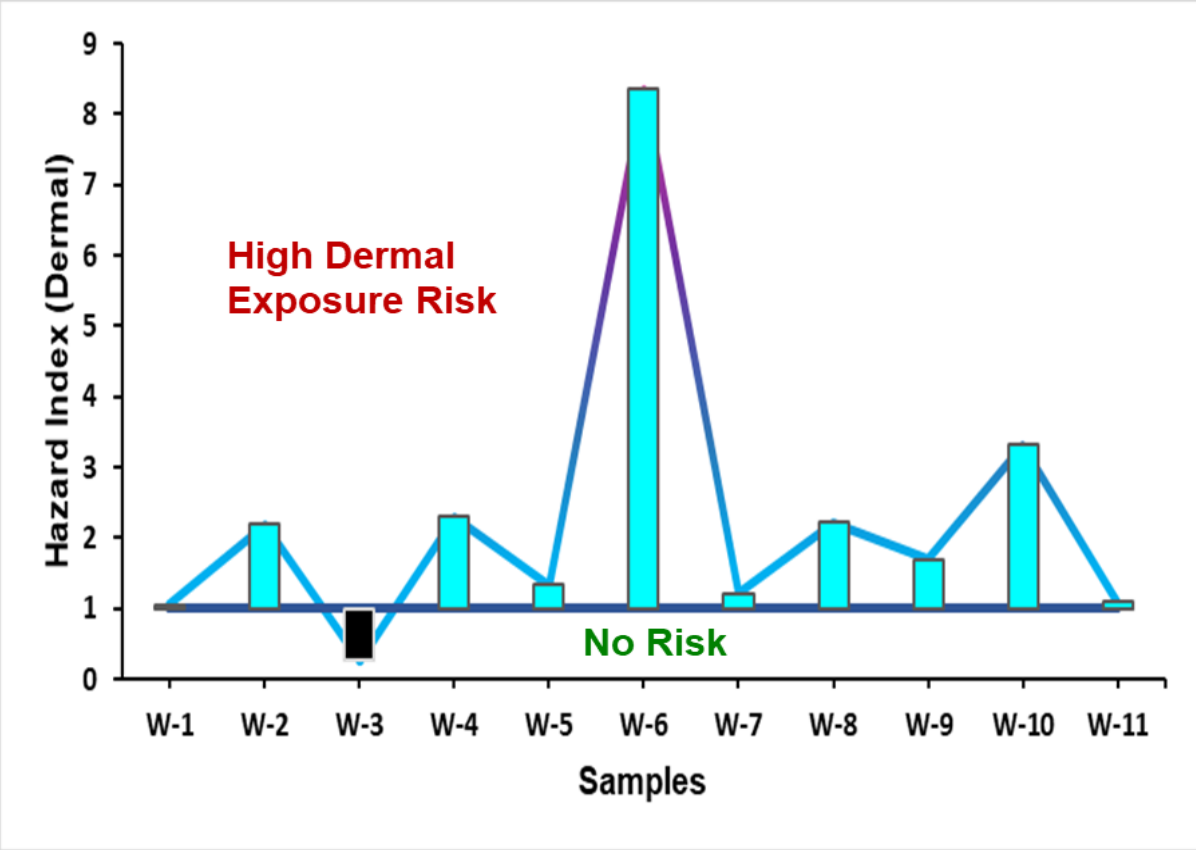


Figure 9: Non-Carcinogenic Risk assessment of groundwater for oral ingestion.

Health Risk Assessment



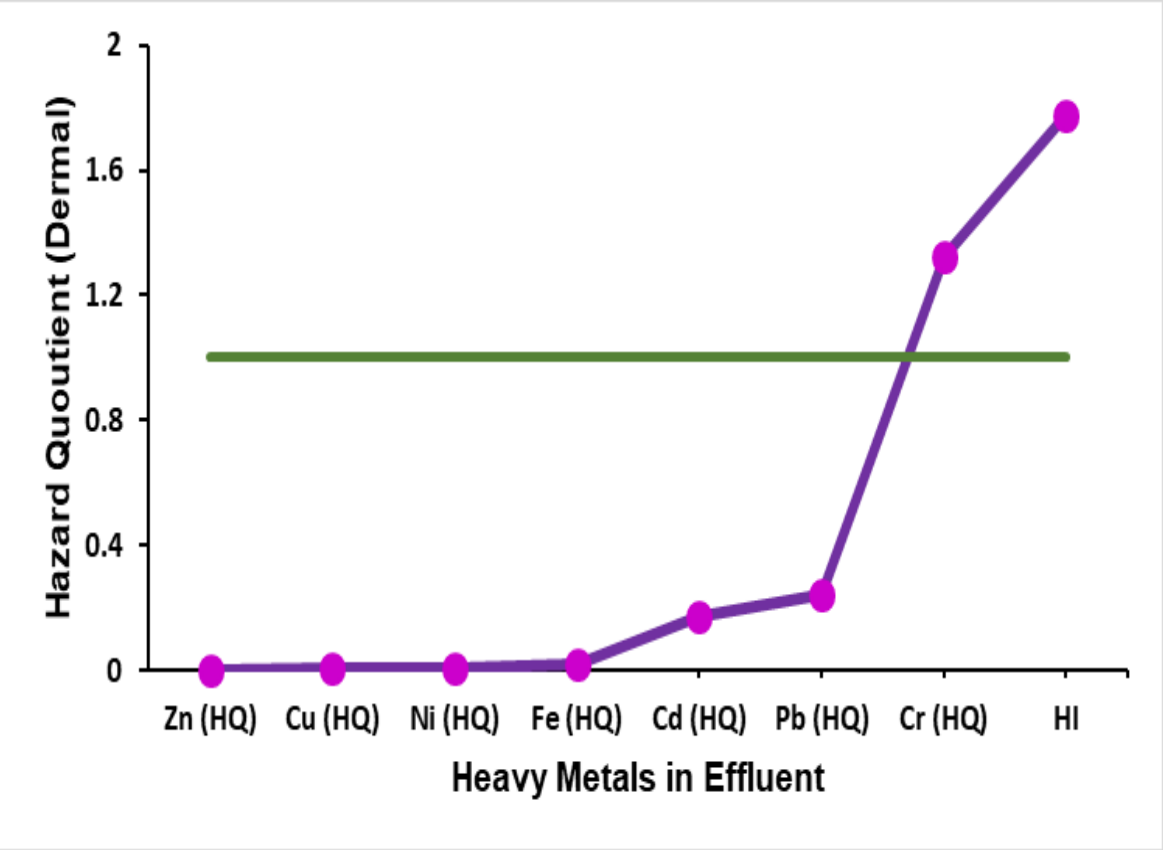
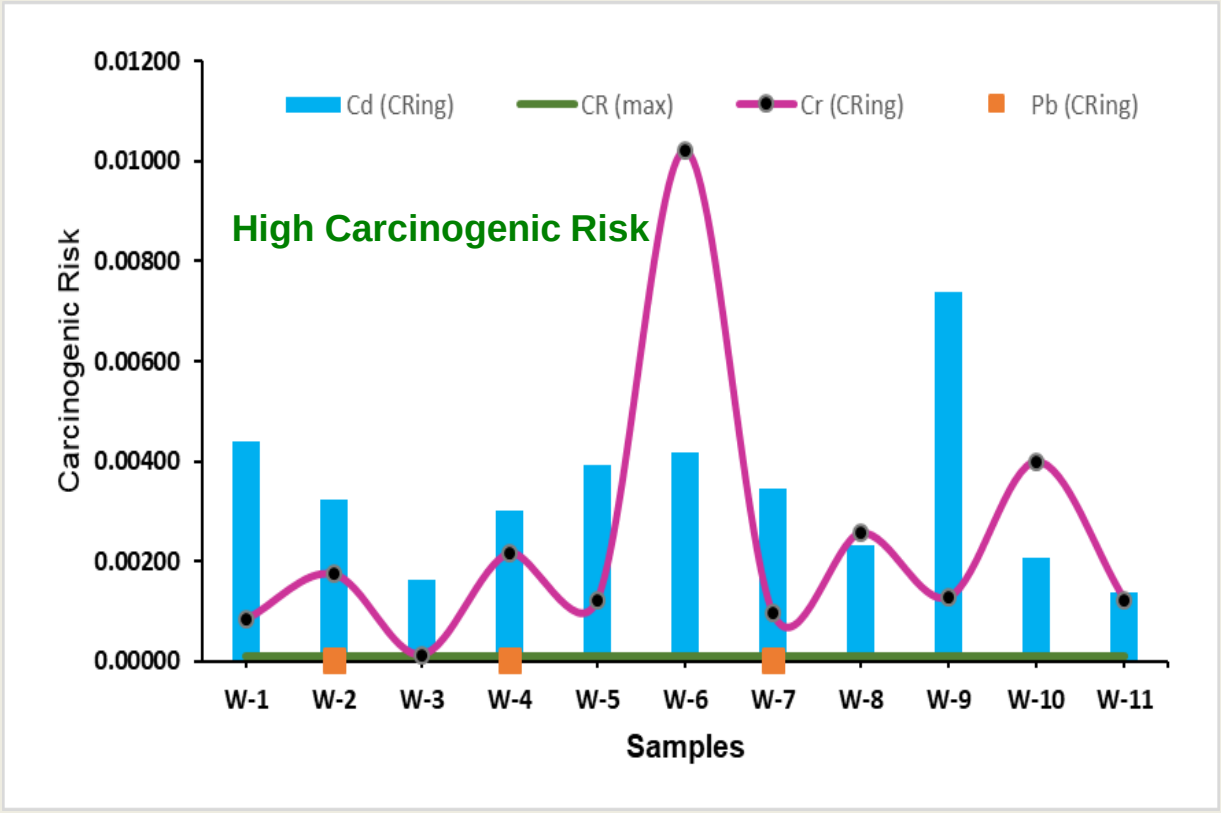


Figure 10: Non-Carcinogenic Risk assessment of GW and Effluent samples for dermal exposure.

Health Risk Assessment



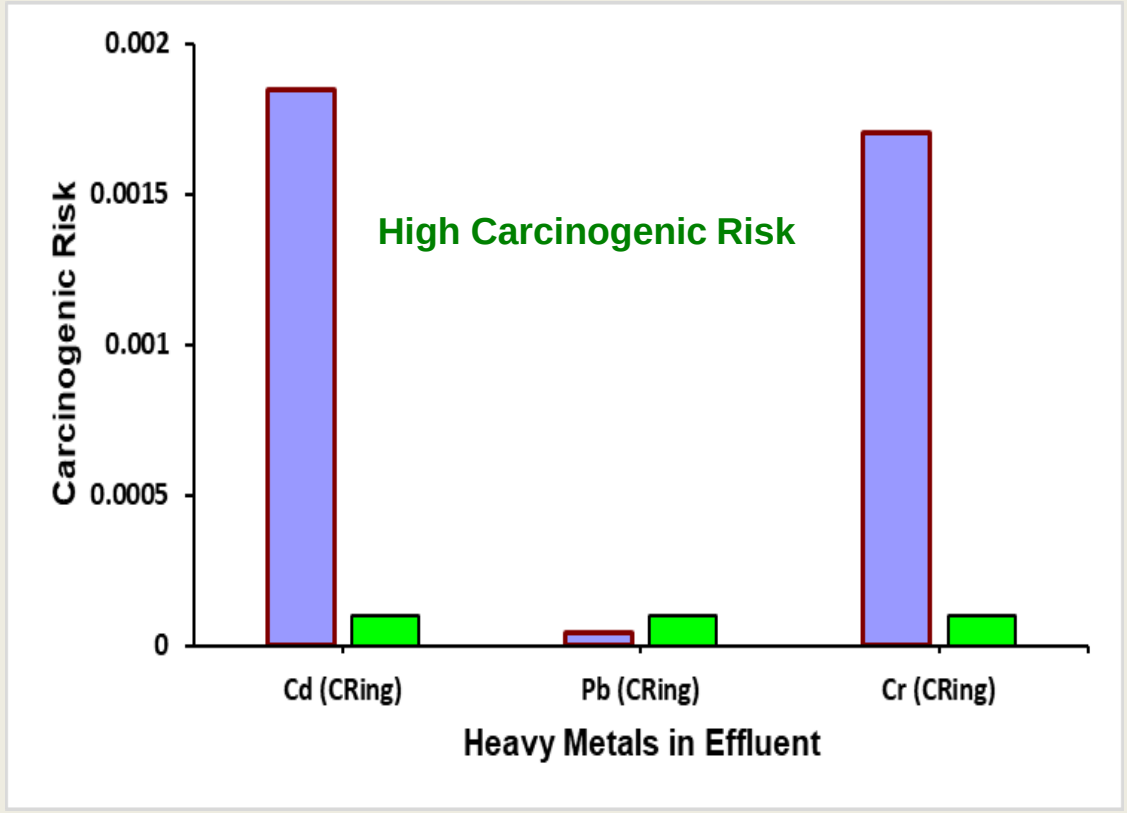


Figure 11: Carcinogenic Risk estimation of groundwater and effluent samples

Corrosion Study

Corrosion is a complex series of reactions between the water and metal surfaces and materials in which the water is stored or transported. Corrosive groundwater, if untreated, can dissolve lead and other metals from pipes and other components present in household plumbing.

Table-3: Corrosivity study of groundwater

Corrosion Parameter	Equation	Classification	Samples
Langelier Saturation Index (LSI)	**$LSI = pH - pH_s$** **$pH_s = (9.3 + A + B) - (C + D)$** **$A = (Log_{10}(TDS) - 1)/10$** **$B = -13.12 \times Log_{10}(T + 273) + 34.55$** **$C = Log_{10}(Ca^{2+}) - 0.4$** **$D = Log_{10}(Alk)$**	**LSI<0:** Water is not saturated and has corroding tendency **LSI = 0:** Water is saturated and has no scaling tendency **LSI>0:** Water is supersaturated and has scaling tendency	**All samples (11)**
Aggressive Index (AI)	**$AI = pH + Log_{10}(Alk \times Ca^{2+})$**	**AI<10:** Water is severely corrosive (highly aggressive) **10≤AI≤12:** Water is moderately corrosive **AI>12:** Water has scaling tendency and has non-aggressive tendency	**All samples (11)**

Corrosion Study

Table-3: Corrosivity study of groundwater (cont.)

Corrosion Parameter	Equation	Classification	Samples
Ryzner Stability Index (RI)	$RI = 2pH_s - pH$	**RI≤ 5.5:** Water has rigorous scaling tendency **5.5<RI<6.2:** Water has scaling tendency **6.2≤RI≤6.8**: Water is balanced and has no scaling or corrosive tendencies **6.8<RI<8.5**: Water has corrosive tendency **RI ≥ 8.5**: Water has rigorous corrosive tendency	**All samples (11)**
Puckorius Scaling Index (PI)	$PI = 2pH_s - pH_{eq}$ $pH_{eq} = 1.465 \times Log_{10}(Alk) + 4.54$	**PI<6**: Water has scaling tendency **6≤PI≤7**: Water has little scaling and corrosive tendencies **PI>7:** Water has significant corrosive tendency	**All samples (11)**
Corrosivity Ratio (CR)	$CR = [(Cl^-/35) + \{(2 \times SO_4^{2-})/96\}]/[\{2 \times (CO_3^{2-} + HCO_3^-)/100\}]$	**CR < 1:** Recommended to the transport of any source of water in any kind of pipes **CR > 1**: Corrosive nature of water, means not to be transported through metal pipes	**All samples (11)**

Corrosion Study

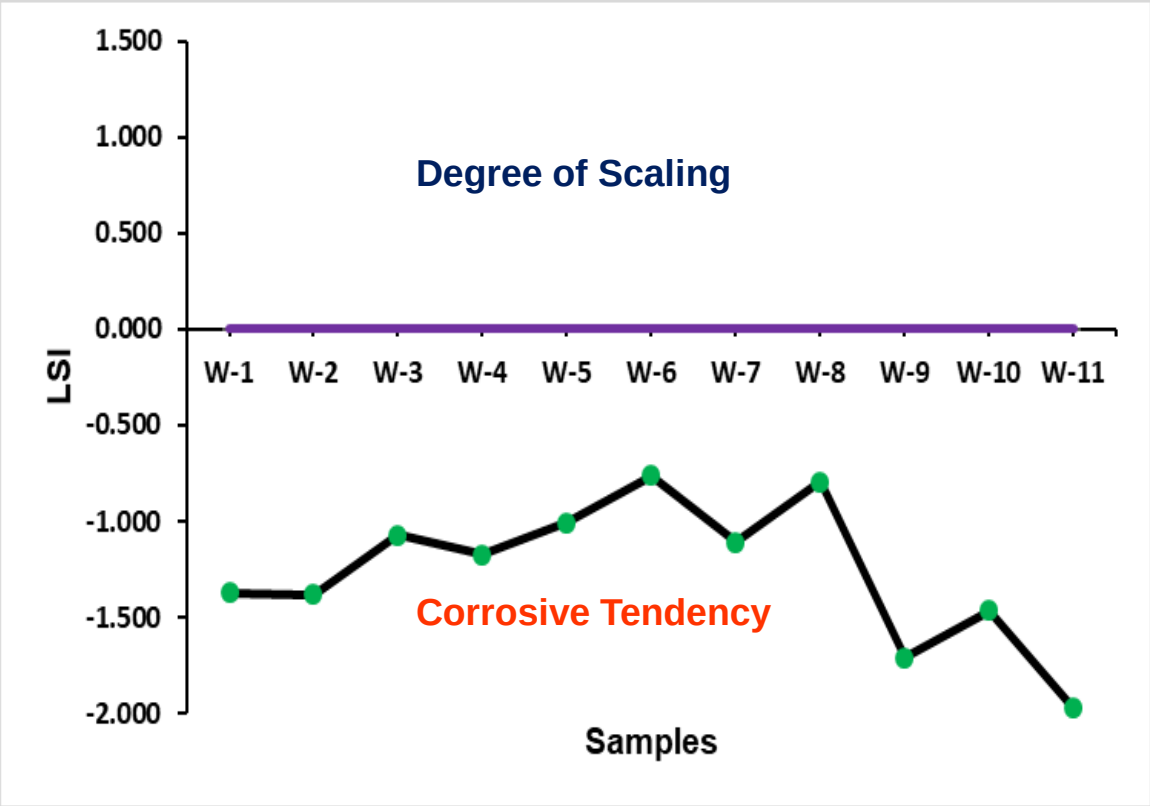


Figure 11: Langelier Saturation Index in GW

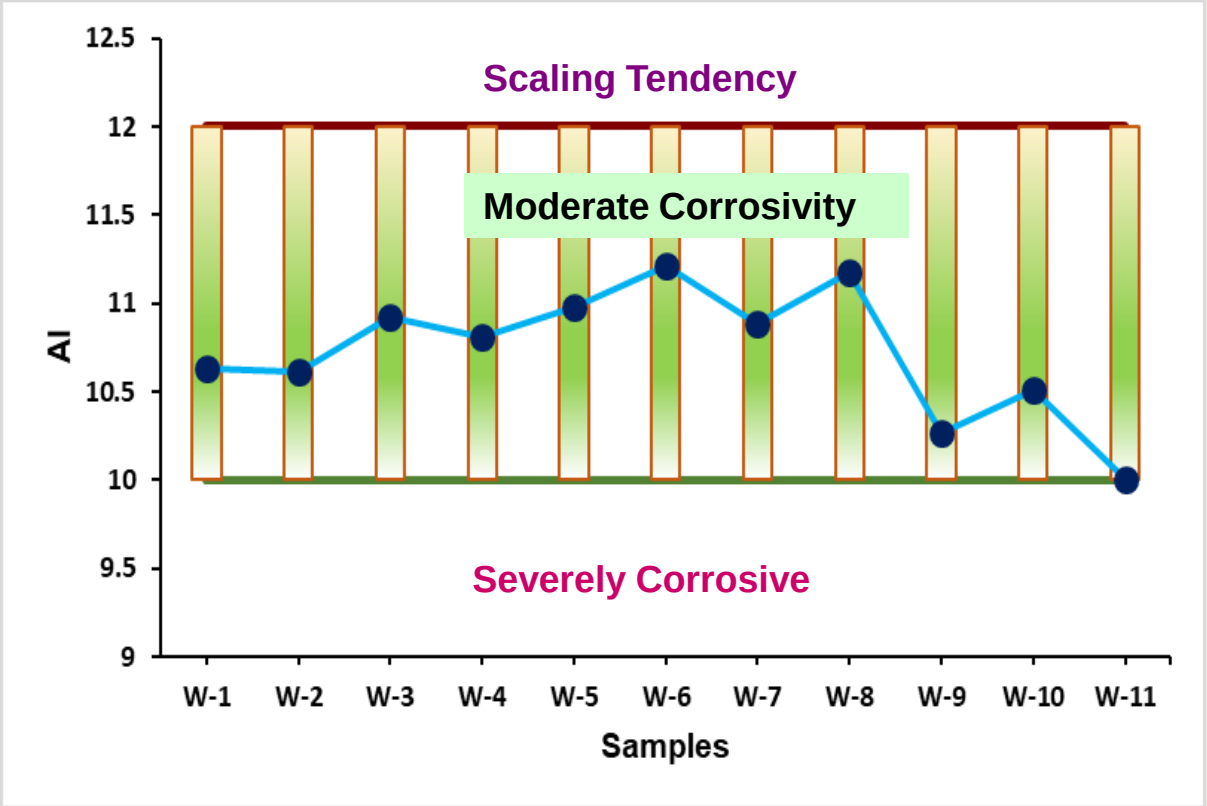


Figure 12: Aggressive Index showing groundwater corrosivity

Corrosion Study

Table-4: Correlation analysis of Corrosion indices with some physical and chemical parameters.

Variables	*LSI*	*AI*	*RI*	*PI*	*pH*	*EC*	*TDS*	*Salinity*	*TA*	*TH*	*Cl⁻*
LSI	1.000										
AI	**0.999**	1.000									
RI	**-0.964**	**-0.964**	1.000								
PI	**-0.792**	**-0.794**	**0.926**	1.000							
pH	**0.632**	**0.624**	-0.424	-0.079	1.000						
EC	-0.134	-0.104	0.024	-0.140	-0.418	1.000					
TDS	-0.210	-0.182	0.097	-0.077	-0.441	**0.968**	1.000				
Salinity	-0.106	-0.076	0.004	-0.141	-0.407	**0.952**	**0.897**	1.000			
TA	**0.694**	**0.695**	**-0.853**	**-0.976**	-0.033	0.136	0.068	0.161	1.000		
TH	-0.033	-0.003	0.009	-0.019	-0.243	**0.779**	**0.766**	**0.871**	-0.027	1.000	
Cl⁻	**-0.623**	**-0.632**	**0.641**	**0.582**	-0.203	-0.130	-0.021	-0.120	-0.465	-0.065	1.000

Conclusion

Conclusion

Thank You All