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Study of Physico-Chemical Characteristics of Surface and Ground Water in Raipur Region of Chattisgarh (India)

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Abstract: ***Water is one of the most important and essential component of the ecosystem. The quality of water is determined by its physical, chemical and biological nature. The present studies has been focused on physico-chemical parameters to determine the pollution level in major surface and ground water bodies of Raipur region supplying potable water to a large number of population. The result of present work reveals that surface and ground water collected from all sites show alkalinity except site 6 where as parameters such as TS, TSS, TDS, T-H, alkalinity, sulphate, Na, K and Fe conc. values are highest at site 4 whereas in case of ground water these parameters shows highest degree of occurrence at site 4 including chloride and conductance.***

Keywords: Ground water, surface water, physico-chemical parameters, analysis, water pollution

1. Introduction

The Quality of surface and ground water is a very sensitive issue in the present scenario. Ponds & rivers play major role in controlling the global hydrologic cycle. These are the most dynamic part of water transport system. Ponds and rivers are the vital and vulnerable freshwater ecosystems that are critical for the sustenance of all life **[1, 2].** However, the declining water quality of these ecological system threatens this sustainability and is a matter of serious concern. River water is a major source of water for various domestic purpose. The surface water quality is deteriorating due to anthropogenic activities, industrialization, farming activities, transportation, urbanization, animal and human excretions and domestic wastes **[3].** Variation in the quality and quantity of river water due to natural and anthropogenic activities is widely studied in the case of many international rivers. It is a common practice for people living along the river catchments to discharge their domestic waste as well as human excreta into rivers **[5].** The quality of water may be described according to their physico-chemical and micro-biological characteristics. For effective maintenance of water quality through appropriate control measures, continuous monitoring of a large number of quality parameters is essential **[4**]. However it is a laborious task to regularly monitoring of all the parameters even if adequate manpower and laboratory facilities are available **[5].**

Surface water is naturally replenished by precipitation and lost discharge to the oceans, evaporation and sub-surface seepage. Oceans contain 97.0% of the earth‟s water while the remaining 3% is classified as fresh water. Seventy-seven percent of this surface freshwater is stored as ice and 22% as ground water and soil moisture. The remaining freshwater, making up less than 1% of the world total, is contained in lakes, rivers and wetlands. Water has many purposes throughout the world, aside from human consumption and purposes related to that. 70% of the earth‟s surface covered with water, it makes the most common substance on earth. There are 326 million cubic miles of water on earth **[6].**

Chhattisgarh is one among the few states of India, which has vast natural resources. The state receives adequate rainfall (average annual rainfall is 1240mm). Here the annual water available per person is 3000 m^3, which is much higher than the national annual average of 1100 m^3 per person **[7].** Thus ground water development of 20%, Chhattisgarh is lagging behind in water resource utilization as compared to the nation as a whole **[5]**. Ground water is a precious and the most widely distributed resources of the earth and unlike any other mineral resources. It gets its annual replenishment from the meteoric precipitation **[8**]. The world water resources are estimated $1.36x10^8$ million ha-m. Out of these, about 97.2% is salt water of oceans, and only 2.8% is available as surface water and 0.65 as ground water. Out of this 0.6% of stored ground water, only 0.25% can be economically extracted with the present drilling technology **[9,10]**. The total areas cultivated in India using ground water has increased from 6.5 million hectare in 1951 to 35.38 million hectare in 1993**[11]**.

2. Materials and Method

2.1 Demography Details of the Study Area:

Raipur is located at Coordinates: 21.14°N 81.38°E effects of water pollution on affected environmental receptor due to site- specific monitoring is to be analyzed. The chief objectives for the present work are:1. To characterize the surface water and ground water for the physiochemical parameter (pH,TS, TSS,TDS, Turbidity, Conductance, Alkalnity, Hardness, SO_4^-, Cl^-, Na^+, K^+, Ca^+, Mg^+). 2. To determine the surface and ground water pollution due to heavy metal (Pb and Cd)

2.2 Study Design

The goal of the work is to evaluate the selected surface water and ground water contaminants in relation to impact of Raipur region. The objective undertaken to fulfill the need of the goal are:

1) Identification of sampling region of Raipur city using meteorological parameters and population of the area.
2) Sampling and characterization of samples of Surface and Ground water matrices selected identified sampling sites.
3) Assessment of selected Physiochemical parameter of Surface and Ground water contaminants in selected environment matrices.

2.3 Sampling Design

To achieve the objectives, a non –probability based longitudinal stratified random sampling plan in space time frame work has been decided **[12]**. On the basis of layout map and the development plan, population density and human activity pattern of the study area has been utilized for the identification of sampling sites **[7].**On the basis of previous wind rose, layout map and population of the area, eight sampling regions around the surface waters and ground water within downwind direction and upwind direction. We have decided the sampling site in Raipur municipal corporation in the direction north ,south , east and west. Description of sampling site is presented in **Table 1** Location map of sampling site for surface and Ground water at Raipur region is given in F**ig.1**

Table1: Description of sampling site for Surface and Ground Water at Raipur region.

Site no	Direction	Wind Characteristics	Name of the Site
1	South East(SE)	Calm & Clear	Katora Talab
2	North east (NE)	Calm & Clear	Raja Talab
3	East(E)	Calm & Clear	Telibadha Talab
4	South(S)	Calm & Clear	Burha Talab
5	North(N)	Calm & Clear	Kachna Talab(Mova)
6	South(S)	Calm & Clear	Tikkra Para Talab
7	West(W)	Calm & Clear	Sarona
8	South(S)	Calm & Clear	Satvhaniya Para Talab

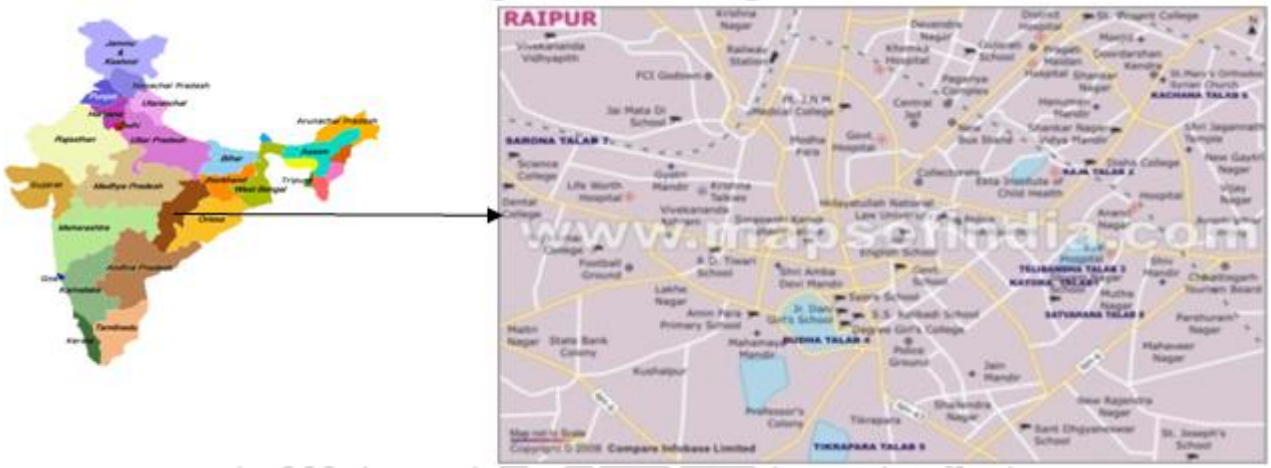

Figure 1: Location map of sampling site for surface and Ground water at Raipur region.

2.4 Sample Collection and Transportation

Specialized cleaning and sampling techniques were used during all stages of sample collection to prevent contamination. All containers and equipment used for surface water and ground water sampling were cleaned using a dilute liquid soap followed by a hydrochloric acid solution and multiple rinses in ultrapure, deionized (DI) water, following the standard protocol **[13]** .

Surface Water and ground water samples (250 ml) of identified natural ponds were collected in pre-washed polyethylene bottles. The bottles were filled up to neck and then added few drops of acid mixture (Sulfuric acid H_2SO_4 and Hydrochloric acid HCl, 1:1) to maintain the pH about 1-2. In each sampling region, 4-5 random points were chosen to collect surface water and groundwater samples. Samples of all sampling points in a specific region have been mixed together to form one representative sample of the region. In case of groundwater sampling, the bore-well pumps were operated for 3-5 minutes before the collection of samples to obtain representative samples. All collected samples were chilled immediately on wet ice chamber and stored at 5°C or less until chemical analysis and transported to laboratory for further analysis **[14].**

3. Results and Discussion

All the measurement data has been analyzed statistically for the mean and standard deviations of multiple measurement of different distances. The spatial variability has been determined across the sites located in different distances within an effluent stream. Parameters and methods employed in the physicochemical examination of water samples shown in Table 2.The statistical analysis of Surface water has been presented in Table 3 and statistical data of Ground water has been presented in Table 4. Spatial distribution of each physico- chemical parameter has been shown in figure 2 to 5

Table 2: Parameters and methods employed in the physicochemical examination of water samples

S. No.	Parameters of water analysis(units)	Method Employed
1.	pH	Potentiometric
2.	Conductance	Potentiometric
3.	Turbidity (NTU)	Nephelometric
4.	Total Solid (TS) (mg/l)	Gravimetric
5.	Total Dissolved Solid TDS (mg/l)	Gravimetric
6.	Total Suspended Solid TSS (mg/l)	Gravimetric
7.	Total Hardness TH (mg/l), Ca-H, Mg-H(mg/l)	Titrimetric
8.	Total Alkalinity TA (mg/l)	Titrimetric
9.	Na^+, K^+ (mg/l)	Flame Photometric
10.	Cl^- (mg/l)	Titrimetric
11.	SO_4^- (mg/l)	Spectrophotometric
13.	Fe(mg/l)	Spectrophotometric
14	Pb(mg/l)	AAS
15	Cd(mg/l)	AAS

Surface Water Results

Result has shown significant variability among selected chemical parameters across the sampling site. Following inferences has been drawn from the data presented in Tables 3 and Graphs 2 - 3:-

Table 3: Physico-Chemical Characteristics of Surface Water Collected at Identified Sampling Sites.

Parameters	Site-1	Site-2	Site-3	Site-4	Site-5	Site-6	Site-7	Site-8
pH	7.70±0.38	8.51±0.26	7.67±0.32	8.20±0.27	7.77±0.24	8.51±0.41	6.98±0.32	8.40±0.22
COND.	1.33±0.12	1.17±0.19	1.89±0.14	1.58±0.09	3.55±0.17	0.18±0.05	1.47±0.12	3.16±0.18
TUR.	5.0±0.05	16.0±0.07	4.0±0.06	18.0±0.04	2.0±0.08	16.0±0.02	106.0±0.04	8.0±0.06
TS	0.40±0.11	0.33±0.09	0.65±0.41	0.82±0.34	0.32±0.12	0.56±0.19	0.40±0.21	0.47±0.10
TDS	29.14±0.25	35.56±0.74	46.23±0.14	47.98±0.35	30.09±0.54	25.54±0.47	32.54±0.24	28.14±0.25
TSS	4.2±0.78	3.6±0.36	5.8±0.14	6.1±0.36	3.5±0.14	4.2±0.36	3.15±0.14	3.2±0.24
T-H	195.0±12.32	225.14±29.25	230.00±14.14	252.36±15.00	162.50±25.36	142.56±54.23	167.50±17.25	142.87±20.21
Ca-H	132.50±15.00	145.00±31.09	162.50±12.58	177.50±15.00	105.00±42.03	87.50±52.00	112.50±26.23	87.50±25.00
Mg-H	62.50±5.00	75.00±20.00	67.50±17.08	80.00±25.17	57.50±22.17	55.00±36.97	50.00±14.14	54.12±36.14
T-A	42.50±22.17	60.00±23.09	107.50±22.14	122.50±46.45	102.87±47.25	90.00±48.99	62.50±5.00	85.12±35.12
Cl^-	0.35±0.13	0.38±0.18	0.62±0.30	0.51±0.32	0.34±0.35	0.32±0.07	0.26±0.11	0.34±0.15
Na^+	19.58±0.12	21.47±0.47	25.14±0.18	28.56±0.58	12.58±0.57	14.25±0.36	10.25±0.69	12.39±0.25
K^+	5.69±0.58	5.68±0.20	9.58±0.36	10.25±47	6.55±0.36	5.21±0.35	4.26±012.04	2.36±0.25
SO_4	0.15±0.04	042±0.07	0.34±0.36	0.45±0.13	0.20±0.11	0.19±0.09	0.23±0.07	0.32±0.14
Fe	0.66±0.25	0.21±0.78	0.69±0.47	0.78±0.25	0.45±0.78	0.32±0.25	0.14±0.25	0.23±0.06
Pb	0.0038±0.24	0.001±0.04	0.0021±0.01	0.0041±0.004	0.0117±0.03	0.0010±0.225	0.0136±.0.05	0.0293±0.36
Cd	0.0169±0.058	0.0175±0.008	0.0166±0.25	0.0170±0.005	0.0169±0.036	0.0160±0.007	0.0163±0.014	0.0171±0.004

The pH values of all sites are within a range from 6.98 to 8.51. Among these expects site no.7 (6.98) all the sites shows alkalinity. The spatial distribution pattern of surface water across the sampling sites has shown uniform distribution pattern. The highest value of pH has been obtained at site no. 2 (8.51) and lowest value site no.7 (6.98).

Conductance, Turbidity and Total Solid (TS) have been shown similar pattern of spatial variation across the sampling site the highest and lowest level of variance from 3.55 -0.18 mS(Conductance) ,0.82-, 0.33 mg/l (TS), 106.0 - 2.0 ntu(Turbidity).

Total Suspend Solids (TSS) are the materials in water that affect the transparency or light scattering of the water. TSS is typically composed of fine clay or silt particles, plankton, organic compounds, inorganic compounds or other microorganisms. These suspended particles range is in size from 10-0.1 mm, in standardized laboratory tests, TSS is defined as the material that cannot pass through a 45 µm diameter filter. Highest value of TSS is found in site no. 4(6.1mg/l)and lowest value is found in site no. 7 (3.1mg/l).

Total dissolved solid (TDS) have been shown similar pattern of spatial variation across the sampling site, the highest and lowest level of variance from 47.98 -25.54 mg/l. Site no. 4 having highest value of TDS is 47.98mg/l and lowest value of TDS is 25.54mg/l at site no. 6 .

Total hardness (TH) has also shown significant spatial distribution (252.36 mg/l) at site no. 4 and lowest value is 142.56 mg/l site no.6. These value are observed within the permissible limit as compared to Indian Standards(300-600mg/l).Similarly Site no. 4 has shown highest concentration of calcium and Magnesium hardness 177.5mg/l and 80.0 mg/l respectively compared to prescribed limits(75-200 mg/l and 30-100mg/l).

Total alkalinity (TA) levels were obtained within maximum permissible limit (200-600mg/l), highest value of total alkalinity has been observed in site no .4(122.50 mg/l) and lowest value at site no 1(42.50 mg/l).

Chloride and sulphates have shown concentration levels within the permissible limits. Chloride has shown highest value at site no. 3 (0.62mg/l) and lowest value at site no.

7(0.26mg/l). Sulphates has shown highest value at site no. 4 (0.45mg/l) and lowest value at site no. 1 (0.15mg/l).

Sodium and Potassium are having highest degree of distribution pattern (28.56mg/l and 10.25 mg/l) at the site no 4. Remaining sites have shown controlled concentration of sodium and potassium compared to maximum permissible limit.

In case of iron concentration all site have shown high concentration of the permissible limit, highest iron concentration has shown at site no. 4 (0.78mg/l).

Lead and Cadmium have highest degree of distribution pattern (0.0293mg/l and 0.0175 mg/l) at the site no. 8 and site no.2.

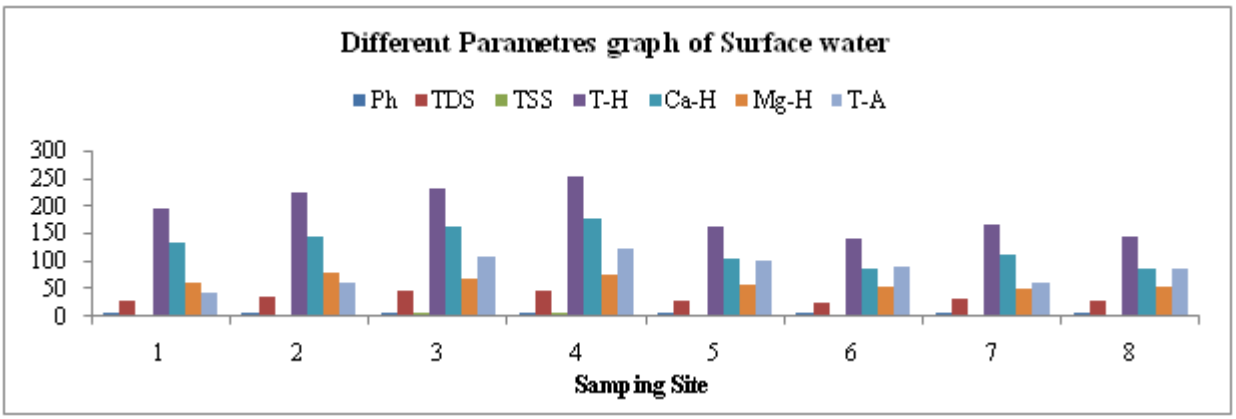

Figure 2: Physicochemical parameter (pH, TDS, TSS, T-H, Ca-H, Mg-H,T-A)of Surface water graph around the sampling site

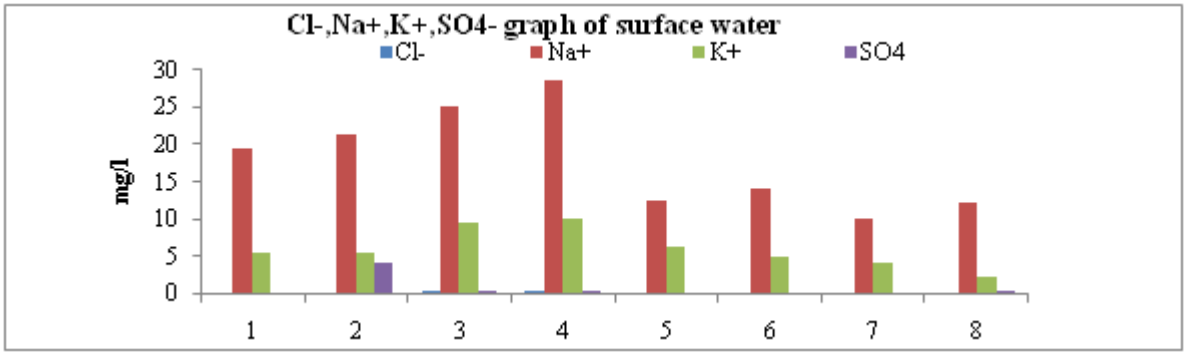

Figure 3: Cl^-,Na^+,K^+,$SO4^-$ graph of surface water

Ground Water Results

Result has shown significant variation among selected chemical parameters across the sampling site. Following inferences has been drawn for the data presented in Tables 4 and Graphs 4-5:-

Table 4: Physico-Chemical Characteristics of Ground water Collected at Identified Sampling Sites

Parameters	*Site-1*	*Site-2*	*Site-3*	*Site-4*	*Site-5*	*Site-6*	*Site-7*	*Site-8*
pH	8.24±0.45	8.18±0.12	7.97±0.15	7.70.±0.08	7.77±0.24	6.95±0.01	8.63±0.52	8.52±0.47
COND.	0.93±0.05	2.39±0.19	1.59±0.58	2.15±0.09	4.75±0.47	1.47±0.09	1.12±0.45	3.07±0.25
TUR.	3.0±0.03	1.0±0.02	6.0±0.07	1.0±0.04	17.0±0.15	1.0±0.05	6.0±0.14	13.0±0.06
TS	4.0±0.25	5.0±0.14	3.0±0.05	6.0±0.47	5.0±0.23	4.0±0.05	3.0±0.14	4.0±0.47
TDS	670.0±25.84	756.0±13.58	945.0±29.47	1026.0±45.15	855.0±52.14	934.0±63.15	733.0±19.12	843.0±32.78
TSS	4.0±0.25	8.0±0.14	5.0±0.05	6.0±0.47	7.0±0.23	9.0±0.05	3.1±0.14	4.0±0.47
T-H	227.67±21.18	198.21±10.69	324.56±12.87	330.47±21.53	178.35±14.12	186.20±10.24	203.00±17.58	194.57±20.45
Ca-H	148.35±11.25	110.32±42.53	207.66±23.41	230.15±32.45	106.45±35.02	112.25±25.42	134.56±12.45	114.67±52.68
Mg-H	79.32±12.45	87.89±23.14	116.69±25.36	100.32±52.36	71.90±23.14	73.95±21.45	68.44±45.86	79.9±54.12
T-A	12.4±0.33	15.6±0.65	20.3±0.48	22.5±0.62	17.4±0.23	11.4±0.20	9.6±0.03	14.5±0.84
Cl^-	72.4±41.2	93.5±69.7	116.9±58.4	109.5±42.6	88.4±45.3	65.7±15.4	84.3±42.8	78.9±11.5
Na^+	41.7±11.2	44.5±23.5	47.1±12.4	54.2±11.2	32.6±2.5	21.4±3.6	35.8±9.0	24.5±13.5
K^+	3.9±0.05	4.6±1.25	6.8±2.35	10.23±1.42	6.34±0.25	7.45±2.30	6.89±1.01	5.34±0.69
SO_4^-	6.1±0.05	5.9±0.85	7.0±0.58	7.4±1.2	6.3±0.59	6.7±0.15	6.4±1.35	6.0±0.09
Fe	0.98±0.05	1.23±0.12	1.31±0.85	1.02±0.08	0.87±0.07	1.06±0.47	0.94±0.07	1.32±0.14
Pb	0.0562±0.014	0.0006±0.004	0.005±0.001	0.017±0.002	0.0095±0.001	0.0110±0.004	0.0119±0.04	0.0093±0.001
Cd	0.0175±0.001	0.0165±0.008	0.0164±0.001	0.0164±0.001	0.0170±0.002	0.0169±0.008	0.0163±0.002	0.0170±0.003

All the samples have shown pH values within the prescribed standards, except site no. 6 pH value is 6.95 . The spatial distribution pattern of ground water across the sampling sites has shown uniform distribution pattern. The highest value has been obtained at site no. 7(8.63) and lowest value at site no.6 (6.95).

Conductance, Turbidity and Total solid (TS) have been shown similar pattern of spatial variation across the sampling site, and the highest and lowest level of variance is from 4.75 -0.93 mS(Conductance), 17.0-1.0 ntu (Turbidity),), 6.0-4.0 mg/l(TS). Conductance and turbidity parameter has shown highest spatial distribution pattern at site no. 5 (4.75 ms and 17.0 ntu). Highest value of Total Suspend Solids (TSS) is found in site no 6 (9.0 mg/l) and lowest value is found in site no. 7 (3.1 mg/l).
Total dissolved solid (TDS) have been shown similar pattern of spatial variation across the sampling site the highest and lowest level of variance is from 1026.0- 670.0 mg/l. The highest value of TDS has shown at Site no. 4 (1026 mg/l) and lowest value has shown at site no. 1 (670 mg/l).

Total hardness (TH) has also shown highest significant spatial distribution at site no. 4 (330.47 mg/l) and lowest value at site no. 5 (178.25 mg/l). These value are observed within the permissible limit as compared to Indian standards (300- 600mg/l). Similarly site no 4 has shown higher concentration of calcium and magnesium hardness i.e 230.15 mg/l and 100.32mg/l respectively as compared to prescribed limits(75-200 mg/l and 30-100mg/l).

Total alkalinity (TA) levels were obtained within maximum permissible limit (200-600mg/l) , highest value of total alkalinity has been observed at site no .4(22.5 mg/l) and lowest value at site no 7 (9.6 mg/l).

Chloride and sulphates have shown concentration levels within the permissible limits. Site no.3 shows high concentration of chloride (116.9 mg/l) and lowest concentration chloride is at site no.6 (65.7 mg/l) . Sulphates have shown highest concentration at site no 4 (7.4 mg/l) and lowest concentration at site no 2 (5.9 mg/l).

Sodium and Potassium have shown highest degree of distribution pattern (54.2 mg/l and 10.23 mg/l) at the site no 4 . Remaining sites have shown controlled concentration of sodium and potassium compared to maximum permissible limit.

All site have shown high concentration of iron in permissible limit. Highest iron concentration is in case of site no. 4(1.31 mg/l) and it is lowest (0.87 mg/l) in case of site no. 5.

Lead and Cadmium are having highest degree of distribution pattern (0.017mg/l and 0.0175 mg/l) at the site no. 4 and site no.1 in permissible limit .

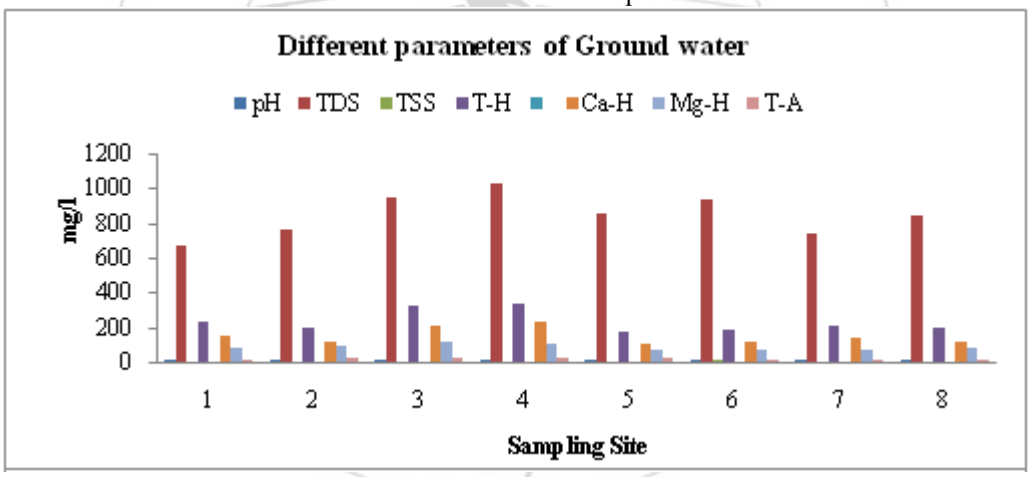

Figure 4: Physicochemical parameter (pH, TDS, TSS, T-H, Ca-H, Mg-H, T-A)of Ground water graph around the sampling site

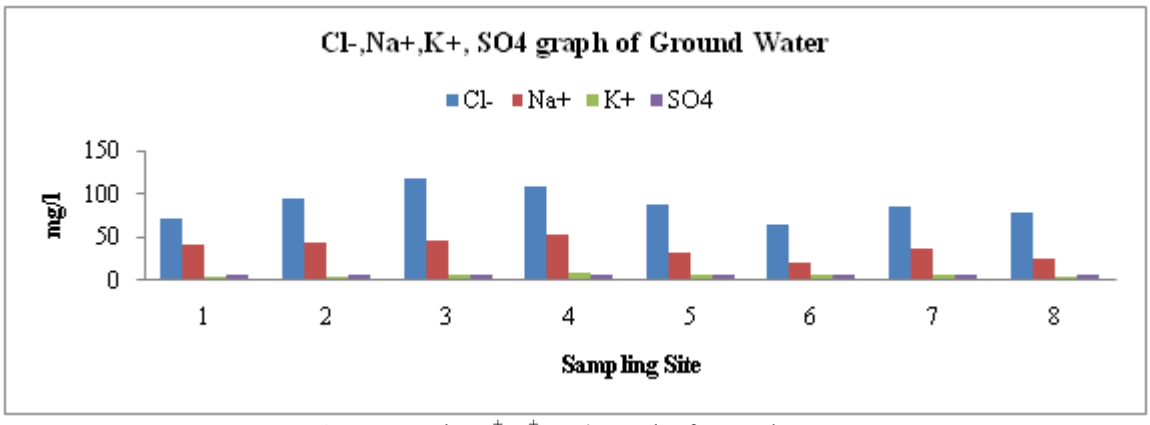

Figure 5: Cl^-,Na^+,K^+,$SO4^-$ graph of ground water

4. Conclusion

The overall study has shown the comparative results of the surface water. pH values of all sites are within a range from 6.98 to 8.51. Among these except for the site no 7, all sites show alkalinity. TS, TSS, TDS , T-H, alkalinity, sulphate, sodium, potassium and iron concentration were having highest value at site no. 4 . Chloride was at highest concentration at site no.3 (0.62 mg/l) and lead concentration was found to be highest at site no. 8 (0.0293mg/l) and cadmium was highest at site no. 2 (0.0175mg/l) . In the case of ground water pH values of all sites are within a range from 6.95 to 8.63. Among these except the site no 6 , all sites show alkalinity. Conductance and turbidity have shown highest value at site no. 5. TS, TDS, T-H, T-A, chloride, sulphate, sodium, potassium showed highest value at Site no.4 . Lead was found to be highest at Site no.4 (0.017mg/l) and Cadmium highest value at site no. 2(0.0175mg/l). These parameters show different pattern of contamination due to the local anthropogenic activities like- automobile emission , domestic used, west deposited and different land use methods.

5. Acknowledgement

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