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Assessment of Ground water quality using Chemical Indices for irrigation use in Kali Nadi Sub basin, Aligarh City, U.P. India

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Abstract: The present paper proposes a structure of appraisal of ground and surface water quality by using chemical indices for irrigation in kali Nadi sub basin, in and around Aligarh city (study area 4023 sq km), situated on the western part of U.P India at a separation of around 126 km from India capital New Delhi. For this, out of 100 water samples, 14 surface and 86 ground water samples were collected and analyzed during pre-monsoon (May) 2015 for the estimation of significant cations, anions, Electrical conductivity (EC), Hydrogen ion concentration (pH), Total dissolved solid (TDS) and Total Hardness (TH). The scientific consequence of the surface and groundwater nature of the study area demonstrates that the order of abundance of cation concentration were Na^{+}>Mg^{2+}+>K^{+}>Ca^{2+} while those of anions concentration were SO_4^{2-} > HCO_3^{-} > Cl^{-} > NO_3^{-}. In light of Revelle Index, the ground and surface water quality is ranging from good to bad for the utilization of human consumption. The Revelle Index Ranges from 0.05-10.0 with mean estimation of 0.84 meq/l .TH, Ec, and pH showed that water is falling in good to permissible water category and Hardness is falling in hard to very hard category. The chemical index, such as SAR, RSC, KI, PI, % Na and MR esteem were computed. The Result of the MR esteems and % Na reveals that the groundwater quality is unacceptable for the water system rehearses in the investigation zone. The PI esteems ranges from 33.98 - 100% with mean estimation of 75.65%. The estimations of MR ranges from 4.3 - 96.1% with mean estimation of 74.2%. Chloro alkaline indices (CAI) 1, 2, figuring demonstrates negative qualities which shown exchange of the Mg What's more Ca of the water for Na and k of the rocks.

Index Terms- Chemical indices, Ground water, Surface water.

1. INTRODUCTION

Groundwater has an imperative part in Indian farming. The appropriateness of water system relies on number of components including, for example, the quality of water, soil type, salt tolerance, characteristic for soil (Michael 1990). During the previous two Decades, the water level in a few parts of India has been falling quickly because of an expansion in water extraction. (Gupta and Deshpande, 2004).

The quantity of wells bored for water system for both food and cash crop have quickly and aimlessly increased. India rapidly rising population and changing way of life have likewise expanded the household, rural and industrial requirement for water. There has been absence of satisfactory thoughtfulness regarding water preservation, efficiency in water utilization, ground water recharge and biological community maintainability.

Groundwater fundamentally contain minute measure of solvent salt which are broken down in it. The kind and quality of these salts depend upon the sources for the recharge of the ground water and the strata through which it flows. The Excess amount of solvent salt might be unsafe for some yields in this way the synthetic arrangement of water is an imperative factor to be considered before it is utilized for local or irrigational purpose. (Suresh et al. 1991).

Kulshrestha (2005) did detailed hydrological, Groundwater Quality and contamination Assessment in Jawa block of Aligarh city and found that the ground water improvement in the block has come to a basic level i.e. concentration of heavy metals show high concentration of iron, lead, manganese, copper, sodium and recommanded that further ground water deliberation from the shallow aquifer should be limited. Dutt (1969) examined the hydrogeology and water logging conditions in Aligarh area. He reported that the drainage from channels has made water logging conditions in the waterway.
The contemplate directed in this range found should bring biological oxygen demand (BOD) of the waterway (an pointer from claiming pollution) close to kohl town of about 100mg/l more than 30

times those standard regarded suitableness for showering (3mg/l) Concerning illustration an after effect every last one of fishes need aid depletion starting with the waterway an implication about concentration of heavy metals show high concentration Exceptionally untreated release arranged in the waterway (Bharat lal seth, Amandeep Kang 2012).

The area rural field had an incredible utilization of compound compost for the product yield and utilization of the water of this kali stream which is as of now very polluted with the contaminants said by the region rural officer. Alongside this kali waterway as the profluent treatment plant is still under development because of the absence of store conceded by the officer of the contamination control board (Bharat lal seth, Amandeep Kang 2012).

The evaluation of groundwater quality is vital for financial development and improvement (Ishaku, 2011) substance arrangement of water might be rendered unfit for human utilization and in this manner prompt medical issues. The significance of groundwater quality in human wellbeing has as of late pulled in a lot of intrigue (Vasanthavisia et al. 2010). In the creating scene, 80% of all ailments are specifically identified with poor drinking water and unsanitary conditions (UNESCO 2006).

The quality status of an aquifer can be evaluated with the utilization and estimation of natural variables and records, which incorporate a wide range of parameter (tziritis et. al 2008) the creators additionally focused on that such factors may turn into a profitable device for the appraisal of ecological states of a range.

2. STUDY AREA

Investigation territory Kali Nadi Sub basin Aligarh India is situated along a Latitude 27^{o} 88' N and Longitude 78^{o} 8' E and covering a region of around 4023 sq. km. The region fall under tropical rainstorm sort of atmosphere. The coldest month of the year are December and January. With a mean temperature extends in the vicinity of 15^{o} C and 12.2^{o}C. The most blazing month of the year are May and June with a mean temperature extends in the vicinity of 32.2^{o}C and 33.8^{o}C. Mean yearly rainfall ranges from 65cm to 75cm but variation of rainfall is considerable large. Mild to Moderate Drought are normal.

About 87% of the aggregate precipitation happens in the time of July and August by South West monsoon (Aziz, 1989). Not a solitary stream channels Aligarh district but rather various streams deplete the city. There are two sorts of streams, the ruling waterways have their source in snow secured mountain scopes of the Himalayas specifically Ganga and the Yamuna that are enduring waterways and other are non-perennial in nature. Himalayan waterways bordering Eastern and Western limits of Aligarh area, Kali Nadi, a non-Himalayan enduring stream beginning from the depression in Muzaffarnagar as well drain the district over growing need of water. Nim, Chhoiya, Rind, Senger, Karban and Patwahaare are the regular rivulets which help their perpetual partners in depleting the area.

Since Aligarh region is Bounded by the stream Ganga and Yamuna, the level of the plain ascents from the extraordinary west of the Yamuna, Khadar to the high uplands towards the middle which covers half of the western part of the tehsil around upto the grand trunk road and after that at last in the further, east the land descends into a slight depression formed by the Kali Nadi. Lifted sand edges are likewise discovered a consequence of the fluvial activity combined with solid westerly winds. In different parts of the tehsil similar edges happen yet the two parallel lines of the high sandy grounds running from North-South in the West of Aligarh city to be said. The subsurface geology of the study area comprises of the Bundelkhand Granitic rock, age (3000 ma) as the basement complex which is unconformably overlain by the rocks of the Upper Vindhyans (Upper Proterozoic) and is finally overlain by the quaternary alluvium. The Quaternary alluvium comprise of exchange beds of sand and clay down to 620 m b.g.l that contain a few aquifer framework in the Central Ganga Basin.

3. DATA & METHOD

In the present investigation, 86 ground and 14 surface water samples were collected from different location of the study area. The samples were collected in clear plastic bottles with no air bubbles. The bottles were washed with distilled water before sampling and firmly fixed after collection and marked in the field. The analysis has been has been carried out on the given procedure by APHA (2003).

3.1. Chemical Estimation:- Analytical review chemicals were set up to prepare reagents and calibration standards. The diverse parameters are evaluated, for example, **pH, EC, Total hardness, TDS, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, NO_3^{-}, F^{-}, SO_4^{-},** as specified in (Table 1) per standard systems suggested by APHA (2003) technique. The water quality parameter values are in mg/l with the exception of pH and EC in µs/cm.

The information were subjected to compute mean, maximum, minimum, standard deviation, as appeared in (Table 2 A, B). Revelle index **<1** indicate good quality water while **>1** determine bad water quality in the examination range. The Revelle index in the investigation territory ranges from 0.05 – 10.0 with mean estimation of 0.84 mg/l. It was assessed that 17% of the water samples having values **> 1** means bad quality water though rest of the 83% specimens are having values **<1** demonstrating the indication of good quality water. It was accomplish that the water of the examination range is in the class of good-bad quality water sort classification.

3.2 Estimation of indices :- Revelle Index, SAR, RSC, Kelley Ratio, Magnesium Ratio, Percentage Sodium, Permeability Index were the lists pre-possessed in this examination.

4. RESULT

4.1 Hydro-geochemical parameter of groundwater:

The Physicochemical framework of the ground and surface water quality data were statistically figure out and the results are conferred in the form of minimum, maximum, mean and standard deviation determined in (Table: 2 A, B). The order of abundance of the cations concentration are **Na^+> Mg^{2+}> K^+ >Ca^{2+}** while those of anions are **$SO4^{2-}$ >HCO_3^->Cl^->NO_3^-.**

The Concentration of Na^+, Mg^{2+}, K^+ and Ca^{2+} varies from 43 to 615, 1.94 to 242.6, 7 to 220 and 6.4 to 256.5 mg/l with mean value of 276, 61.53, 53.85, 30.25 mg/l respectively.

The concentration of anions signifies that $SO4^{2-}$, $HCO3^-$, Cl^-, $NO3^-$ varies from 159 to 4182, 20 to 430, 85 to 582, 0 to 261.7 mg/l with mean value of 483.7, 158.2, 120 and 33.54 mg/l respectively. The pH value varies from 7.8 to 9.5 with an average of 8.8 which reveals the basic condition of ground and surface water quality in the study area.

4.2 Computation of contamination:

The contamination of the groundwater quality of the study area was estimated with the use of Revelle index. Revelle index (R) is particularly use as a criterion of groundwater quality assessment (Tziritis et. al 2008). The calculation of the index is based on the ionic ratio Cl/CO3+HCO3 in mg/l (Revelle, 1946).

4.3 Quality Evaluation of groundwater for agricultural use:

The water quality for irrigational practices is considered under the following indices:

4.3.1 Residual sodium carbonate (RSC):

RSC has been evaluated to see the hazardous effect of carbonate and bicarbonate on the water quality of study area for agricultural purpose (Aghazadeh Mogaddam, 2010) and is estimated by using the formula as mentioned below:

$$\mathbf{RSC = (HCO_3^- + CO_3^{2-}) - (Ca^{2+} + Mg^{2+}) \rightarrow \ (1)}$$

Where all the ions are expressed in mg/l

The RSC values **>1.25 mg/l** are considered safe for irrigational practices while those from **1.25 mg/l to 2.5 mg/l** are considered marginally suitable, whereas RSC values **>2.5 mg/l** of the groundwater is considered unsuitable for irrigational purpose (Richard 1954).

Appendix 1 denotes the computed RSC values ranges from **-24 mg/l to 6.56 mg/l** with mean of **-1.25 mg/l.** Appendix 2 revealed that 70% of the samples are within the safe water category where as 11% of the sample under marginally suitable category and 19% sample are under unsuitable category as for as RSC is concerned.

Hence continued use of this water with high RSC values in the study areas will make the water unsuitable for the cultivation purpose.

4.3.2 Sodium Absorption Ratio (SAR):

If water used for irrigation is high in Na^+ and low in Ca^{2+} the ion exchange complex may become saturated with Na+ which destroy the soil structure, due to the dispersion of the clay particles (Todd 1980) and reduce the plant growth.

SAR is computed using the following equation:-

$$SAR = \frac{Na^+}{\sqrt{\frac{1}{2}\left(Ca^+ Mg^{2+}\right)}} \qquad \rightarrow \qquad \mathbf{(2)}$$

The concentration of ions are expressed in meq/l

USSL (1954) proposed a plot SAR against EC for rating irrigational water (fig 2). It has been come across that 52 number of water samples are falling in good quality water, 43 number of water samples are falling in moderate quality water on the other hand 5 water samples water samples are falling in bad water quality. The computed SAR value in Appendix 1 ranges from **0.82 to 28.8 meq/l.**

4.3.3 Total Hardness (TH):

Total hardness ranges from **60-1540 mg/l** with an average of **329.6 mg/l.** Appendix 2 indicates 53% water samples are falling in hardwater category, where as 35% water samples are falling in very hard water category, 10% in moderately water category and 2% in soft water category. The maximum permissible limit of hardness of water is **600mg/l** according to WHO (2012). Dissolve calcium and magnesium from soil and aquifer minerals containing limestone or dolomite are the main source of water having high hardness.

Hardness of water limit its use for domestic, industrial and agricultural activities. Water hardness can cause scaling of pots,

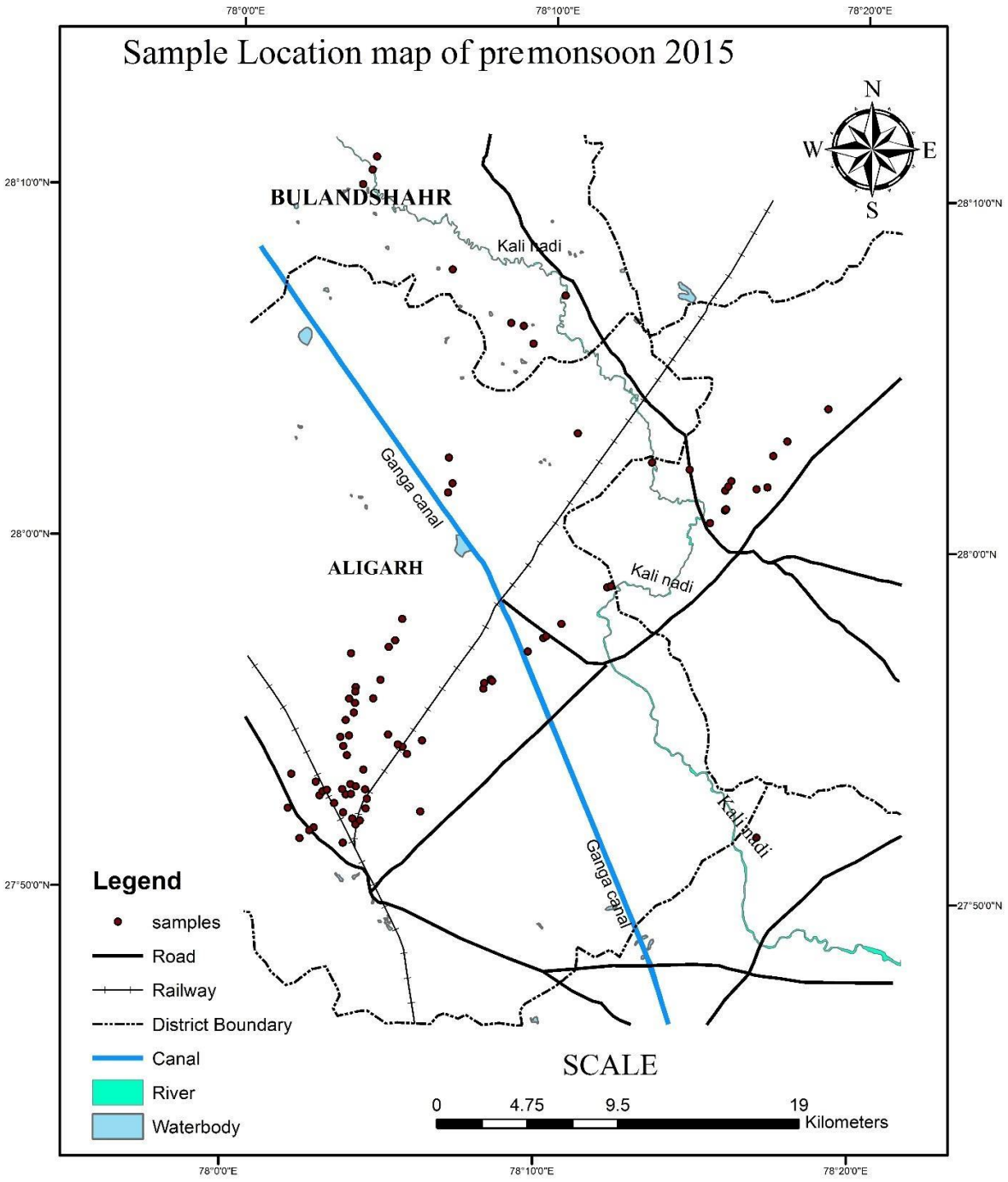

Fig. 1 Location map of the Study Area

Table 1 Methods used for Estimation of Physicochemical Parameters

S.No.	Parameter	Methods
1	PH	PH meter
2	EC	Conductivity meter
3	TDS	Volumetric method
4	Chloride	Silver nitrate method
5	Total Hardness	Titration method
6	Calcium	
7	Magnesium	
8	Sodium	Flame photometer
9	Potassium	
10	Sulfate	Spectro photometer
11	Nitrate	
12	Fluoride	

Table: 2 (A) Summary of **groundwater** quality data in the study area.

	Min	**Max**	**Mean**	**Standard deviation**
PH	7.8	9.5	8.86	0.36
EC	500	2000	883	266
TDS	18	10164	1870	2916
TH	60	1040	281	197
Calcium	6.41	72.1	21.94	13.78
Magnesium	1.94	242.6	54.9	46.2
Sodium	43	615	273	108
Potassium	7	220	45	42
Bicarbonate	20	430	152.5	81.96
Carbonate	20	180	78.13	34.45
Sulfate	159	4182	496	427
Chloride	11	582	116	125
Nitrate	0	261	30	38.9
Fluoride	0	1.96	0.47	0.28
Revelle index	0.08	10.01	0.89	1.52

Table: 2 (B) Summary of **surface water** quality data in the study area.

	Min	**Max**	**Mean**	**Standard deviation**
PH	7.9	9.1	8.55	0.36
EC	500	1100	971	133
TDS	58	9530	2146	301
TH	104	1540	622	429
Calcium	14	256	81	73.2
Magnesium	16	219	102	70.9
Sodium	50	415	295	86.2
Potassium	10	140	104	28.4
Bicarbonate	70	290	192	78.23
Carbonate	60	200	118.5	42.4
Sulfate	173	1057	403	238.7
Chloride	8.52	187.44	145.8	40.9
Nitrate	3.8	87.1	54.9	18.8
Fluoride	0.13	0.8	0.54	0.18
Revelle index	0.05	0.75	0.57	0.16

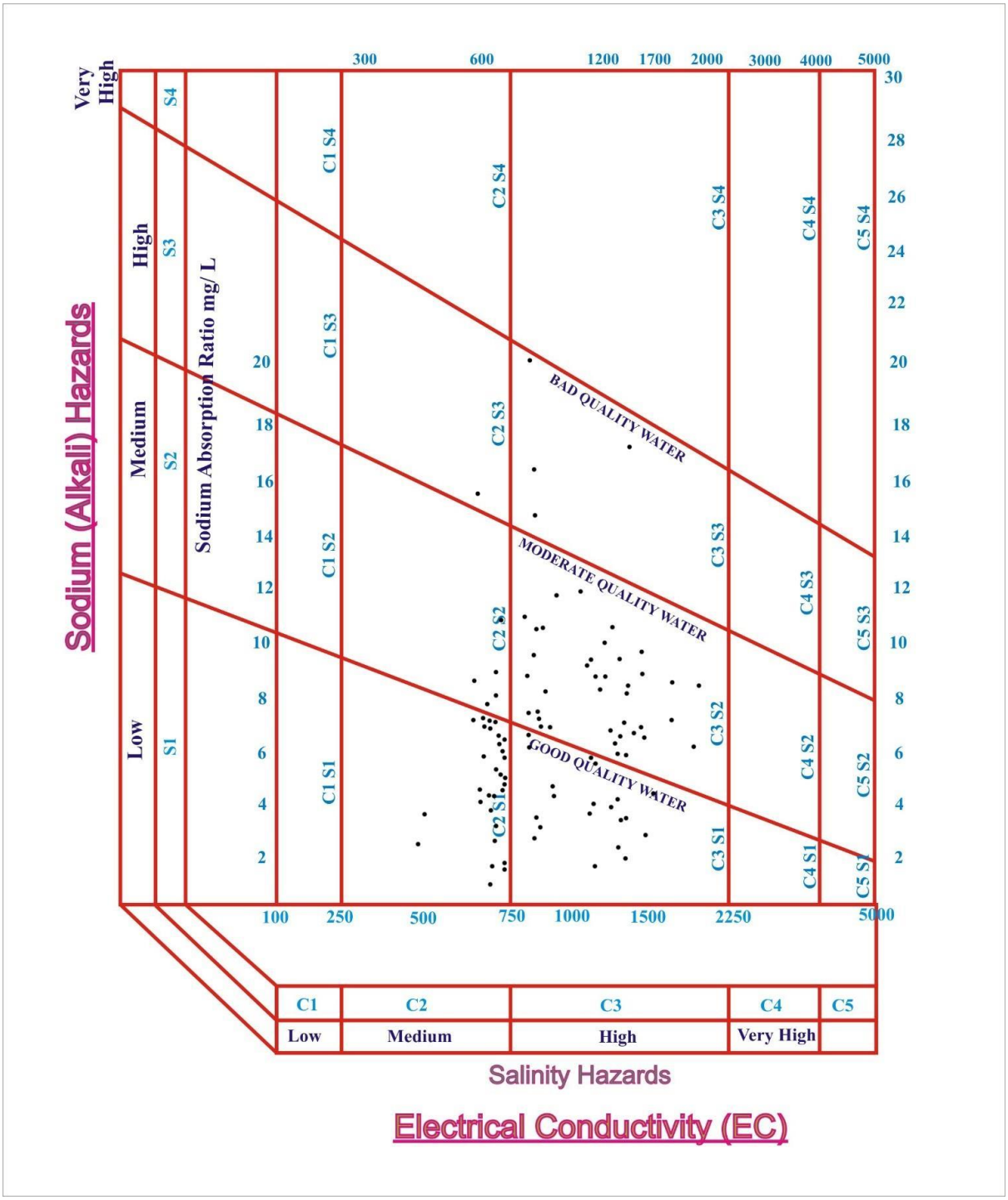

Fig. 2 Plot of SAR values of ground and surface water during the Pre-monsoon 2015 of Study area

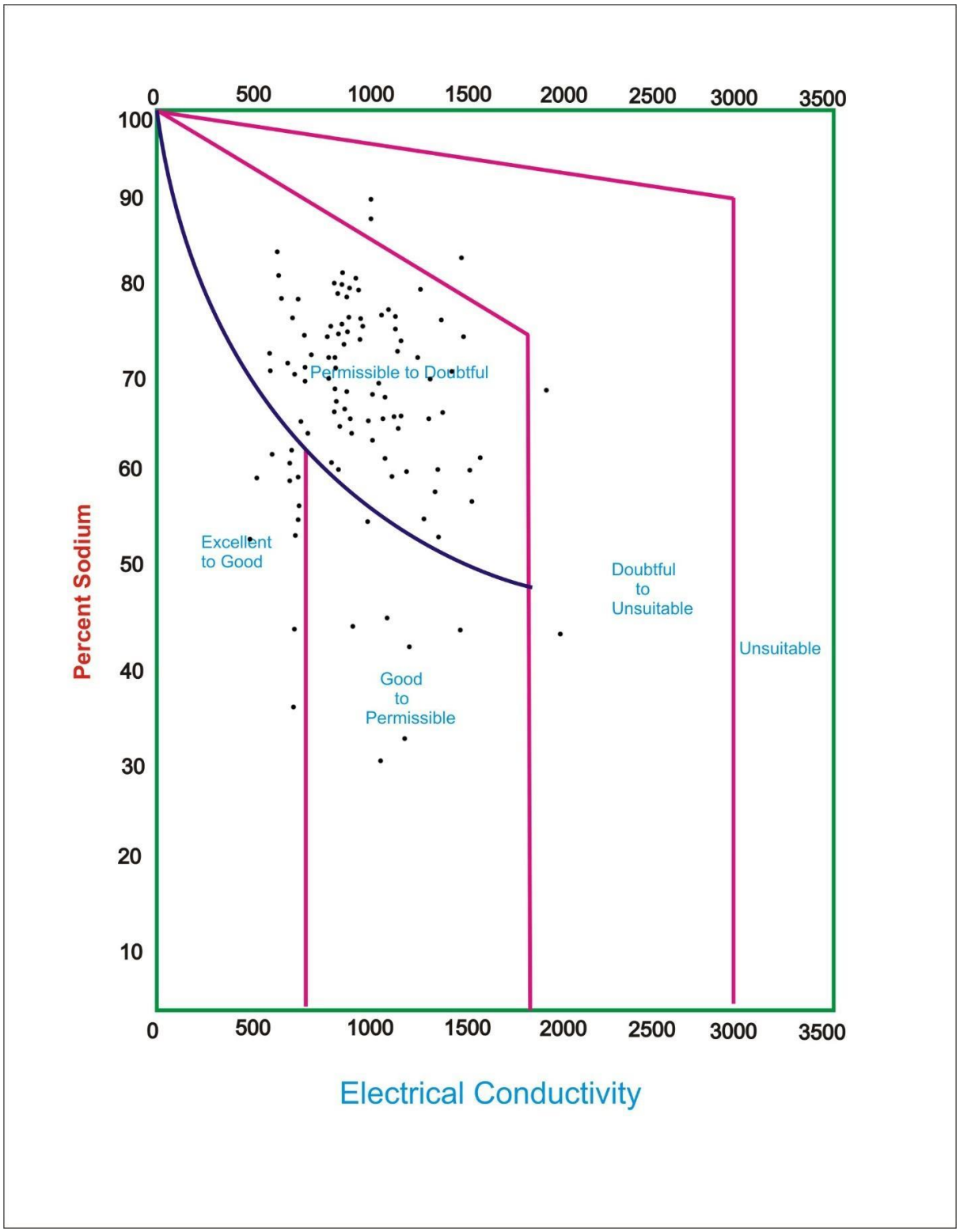

Fig. 3 Plot of sodium percent vs Electrical conductivity of ground and surface water of Study area pre-monsoon 2015 (After Wilcox 1955)

boiler irrigation pipes, it may also cause health problems to human such as kidney failure according to WHO (2012).

4.3.4 Percentage Sodium (%Na): The sodium in irrigation water is usually expressed in %Na (Tank and chandel 2010). When concentration of sodium ion is high in irrigated water, it tends to be absorbed by clay particles dispersing magnesium and calcium ions. This exchange process of sodium in water for Ca^{2+} and Mg^{2+} in soil decreases the eventually result in soil with poor internal drainage. (Tiri and Boudoukha, 2010).

Sodium is an important ion used for the classification of irrigation water due to its reaction with soil reduces its permeability vasanthavigar et al. 2010).

The %Na is computed with respect to relative proportion of cations present in water as:

$$Na\% = \frac{\{Na^+ + K^+\}}{\{Ca^2 + Mg^{2+} + K^+ + Na^+\}} \times 100 \rightarrow \textbf{(3)}$$

Where all the ionic concentration are expressed in mg/l.

Below showing the Wilcox diagram (Na^+ vs EC) of surface and ground water reveals that the maximum number of samples are falling in permissible to doubtful category. Whereas Appendix 2 showing that the majority of the samples are falling in doubtful category, indicating that the water is unsuitable for irrigational practice in the study area.

4.3.5 Electrical Conductivity (EC):

Electrical conductivity (EC) is a measure of waters capacity to conduct electric current. As most of the salts in the water are presents in the form of ions and are responsible to conduct electric current. Generally groundwater tend to have high electrical conductivity due to the presence of high amount of dissolved salt. Electrical conductivity is a decisive parameter in determining suitability of water for particular purpose classified according to electrical conductivity in following classes of excellent, good, permissible and doubtful category shown in appendix: 2.

Appendix 1 indicated that EC values ranged from **500 – 2000 µs/cm** with mean value of **896µs/cm**. As shown in (Appendix 2) the EC values are lying in the category of good to permissible quality water for irrigational practice. 32% of the water samples are falling in good category where as 68% water samples are falling in permissible class.

4.3.6 Kelley Index (K.I):

Kelley's index is used to find whether the groundwater is suitable for irrigational practices or not. It is the ratio of sodium ion to calcium and magnesium ion in epm (Kelley 1951) and expressed by a formula

$$K.I = \frac{Na^+}{Ca^+ + Mg^{2+}} \quad \rightarrow \quad \textbf{(4)}$$

Where all the ions are expressed in meq/l

Ground and surface water possessing kelley's ratio **more than 1** is generally considered unfit for irrigational practices whereas Kelley ratio **less than 1** is considered suitable .The K.I value computed for the study area ranges from **0.41 to 14.4 mg/l** with mean of **2.53 mg/l.** 87% water samples are having the value above (1) hence the water of the study area is unsuitable for irrigation purpose.

4.3.7 Total dissolved solid (TDS):

Salts of calcium, magnesium, sodium & potassium present in irrigation water may pose to be injurious to plants (obiefunaand and she riff 2011). The authors went further to stream that salts from the major ion when present in excess quantities can affect the osmotic activities of the plants may present adequate aeration.

The value of TDS from water samples ranged from **18.2 mg/l to 10164 mg/l** with mean of **1909 mg/l.** All the values are under different class as shown in appendix 2. 64% of the water samples are under the Non-saline class, 22% of the water samples are under the slightly saline class. 13% of the samples under moderately saline class and 1 % samples are falling under very saline class.

4.3.8 Permeability Index (P.I.):

The Classification of irrigation waters has been attempted on the basis of permeability index as suggested by Doneen 1962. It is defined as

$$P.I = \frac{Na + \sqrt{Hco3^-}}{Ca^{2+} + Mg^{2+} + Na^+} \times 100 \rightarrow \textbf{(5)}$$

Where all ions are expressed is meq/l

The P.I values computed for the area ranges **33.98 to 100%** with mean of **75.65%.**

4.3.9 Magnesium Ratio (MR):

Generally, calcium and magnesium maintain equilibrium in most water (Hem, 1985). In equilibrium Mg^{2+} in water will adversely affect crop yield (nagaragu et al. 2006). In measure of the effect of magnesium in irrigated water is expressed as magnesium ratio.

Paliwal (1972) developed an index for calculating the magnesium Hazard (MR). MR is calculated using the formula

$$MR = \frac{Mg^{2+}}{\left(Ca^{2+} + Mg\right)} \times 100 \rightarrow \quad \textbf{(6)}$$

Where all the ionic concentration are expressed in meq/l.

The computed MR values in the study area ranges from **4.3 to 96.1%** with mean of **74.2%.** 89% of

MR value is **>50** making it unsuitable for irrigational purpose where as 11% of MR value is **<50** making it suitable for irrigational purpose. Continued use of water with high magnesium content will adversely affect crop yield, therefore suggest quick intervention.

4.3.10 Indices of Base exchange:

Changes in chemical composition of groundwater along its flow path can be understood by use of the chloro-alkaline indices (CAI). Scholler in 1965, 1977 suggested chloro-Alkaline indices CAI 1, 2 for the interpretation of ion exchange between groundwater and host environment. The Chloro-alkaline indices are calculated from the following indices.

1) Chloro-Alkaline indices

$$I = \frac{\left[Cl - (Na + k)\right]}{Cl} \quad \rightarrow \quad \textbf{(7)}$$

2) Chloro-Alkaline indices

$$l = \frac{\{[Cl - (Na + K)]\}}{SO_4} + \{Hco3 + Co3 + No3\} \quad \rightarrow \quad (8)$$

Positive chloro-Alkaline indices indicate exchange of Na and K from the water with Mg and Ca of the rocks and is **negative** when there is an exchange of Mg and Ca of the water with Na and K of the rock (Nagaraju et. al 2006). In this present investigation CAI_1 value ranges from **-26.96 to -0.08** with mean value of **-6.41** while CAI_2 value ranges from **-2.07 to -0.01** with mean value of **-0.844.** All the computed values of CAI are **negative**, thus indicating exchange of Mg and Ca of the water with Na and K of the Rocks.

5. CONCLUSION:

The surface and ground water quality in Kali Nadi Sub basin, Aligarh city U.P India has been surveyed for the chemical evaluation and suitability for the human utilization and farming use. The request of plenitude of cations fixation are found in the diminishing order of $\mathbf{Na^+ > Mg^{2+} > K^+ > Ca^{2+}}$ while those of the anions are $\mathbf{SO_4^{2-} > HCO_3^- > Cl^- > NO_3^-}$ separately.

Revelle Index, SAR, RSC, Kelley Ratio, Magnesium Ratio, Percentage Sodium, Permeability Index were the records utilized in this investigation. The outcome demonstrate that the surface and groundwater quality status regards terrible quality water for human utilization in view of Revelle list. The groundwater and surface water is weakening step by step and is getting to be noticeably inadmissible for irrigational reason in view of RSC, Kelley proportion and Magnesium proportion. Chloro-Alkaline records 1, 2 counts the negative esteems. The negative esteem shows the exchange of Mg and Ca of the water with Na and k of the Rock.

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Appendix 1 (A): Parameters used for the evaluation of **surface water** quality for irrigational practice

Location	***SAR***	***R.S.C***	***%NA***	***MAR***	***Hardness***	***K.R***	***EC***	***TDS***	***P.I***	***Chloro-Alkaline Indices 1***	***Chloro-Alkaline Indices 2***
1	*1.409316*	*-13.0634*	*45.68503*	*85.26322*	*1020*	*0.704658*	*1000*	*952.4*	*46.72*	*-2.63154*	*-0.61335*
2	*2.342447*	*-7.96304*	*58.05836*	*87.51213*	*760*	*1.171224*	*1000*	*1154.6*	*59.49*	*-3.53129*	*-0.61292*
3	*2.145134*	*-8.40045*	*56.40718*	*86.65207*	*800*	*1.072567*	*1000*	*1075.6*	*54.93*	*-4.50147*	*-1.14758*
4	*3.934516*	*-0.03527*	*69.88556*	*52.01208*	*356*	*1.967258*	*1000*	*701.8*	*71.32*	*-2.95051*	*-0.70468*
5	*2.068316*	*2.378766*	*53.62073*	*65.68018*	*104*	*1.034158*	*500*	*58.6*	*75.89*	*-8.98372*	*-0.21792*
6	*2.520148*	*0.212281*	*61.903*	*56.70451*	*376*	*1.260074*	*1000*	*1023.2*	*63.58*	*-2.04018*	*-0.77888*
7	*2.863394*	*-0.29038*	*64.10607*	*48.24331*	*384*	*1.431697*	*1000*	*987*	*67.74*	*-2.15642*	*-0.65127*
8	*3.604738*	*-0.3973*	*68.37576*	*63.19148*	*388*	*1.802369*	*1000*	*988*	*72.76*	*-2.94156*	*-1.09763*
9	*2.605734*	*-0.57156*	*62.22078*	*60.31363*	*380*	*1.302867*	*1000*	*1052.2*	*67.56*	*-1.36041*	*-0.81286*
10	*3.675596*	*-0.83247*	*68.52878*	*67.63404*	*392*	*1.837798*	*1000*	*1054.2*	*74.11*	*-2.27201*	*-1.6902*
11	*4.112033*	*0.897767*	*70.99561*	*66.17586*	*340*	*2.056016*	*1000*	*992.4*	*76.52*	*-2.98697*	*-1.43704*
12	*3.770781*	*-1.01984*	*68.96655*	*75.77294*	*376*	*1.885391*	*1000*	*986.6*	*75.09*	*-3.00811*	*-1.65819*
13	*0.861325*	*-23.5329*	*34.7367*	*57.65312*	*1500*	*0.430663*	*1100*	*9530*	*35.13*	*-2.48538*	*-0.93396*
14	*0.824851*	*-24.0063*	*33.83463*	*58.75901*	*1540*	*0.412426*	*1000*	*9495.6*	*33.98*	*-2.8429*	*-0.86354*
Min	0.82	-24	33.83	48.24	104	0.4	500	58	54.46	-8.98	-1.6
Max	4.11	2.3	70.99	87.51	1540	2.05	1100	9530	139	-1.36	-0.21
Mean	2.6	-6.14	57.63	66.7	647	1.3	950	2477	93	-3.43	-0.94
STDV	1.11	9.14	12.76	13.03	465	0.55	168	3295	30	2.15	0.44

Appendix 1 (B): Parameters used for the evaluation of **groundwate**r quality for irrigational practice

Location	*SAR*	*R.S.C*	*%NA*	*MAR*	*Hardness*	*K.R*	*EC*	*TDS*	*P.I*	*Chloro-Alkaline Indices 1*	*Chloro-Alkaline Indices 2*
1	*1.504292*	*-1.47835*	*45.43854*	*72.98604*	*220*	*0.752146*	*700*	*371.2*	*59.34*	*-0.90343*	*-0.11834*
2	*6.519819*	*1.288832*	*77.63557*	*63.93862*	*132*	*3.25991*	*600*	*310.8*	*90.77*	*-11.6796*	*-1.26306*
3	*6.343602*	*1.006325*	*76.96835*	*4.308952*	*188*	*3.171801*	*700*	*502.2*	*87.82*	*6.76257*	*-0.657*
4	*7.51433*	*1.699705*	*79.7537*	*80.20854*	*160*	*3.757165*	*700*	*451*	*91.29*	*25.2164*	*-1.44904*
5	*3.277708*	*0.163958*	*64.20633*	*63.09591*	*172*	*1.638854*	*600*	*260.8*	*76.06*	*-11.8048*	*-0.94581*
6	*4.810105*	*0.561343*	*72.0403*	*77.31366*	*192*	*2.405053*	*700*	*372.2*	*83.96*	*-12.7131*	*-0.82529*
7	*14.31695*	*-0.34929*	*87.90536*	*45.15143*	*116*	*7.158475*	*600*	*170*	*91.98*	*-16.4543*	*-0.93802*
8	*3.024655*	*-0.85398*	*61.56088*	*32.2854*	*100*	*1.512328*	*500*	*132.6*	*74.06*	*-3.96496*	*-0.19363*
9	*4.458233*	*0.841391*	*70.1534*	*72.60148*	*188*	*2.229117*	*700*	*289.8*	*78.35*	*-11.2415*	*-0.71429*
10	*6.054689*	*0.386341*	*76.20993*	*46.4792*	*260*	*3.027345*	*900*	*683*	*82.34*	*-6.95968*	*-0.87839*
11	*3.662339*	*-1.13721*	*66.32043*	*45.60743*	*212*	*1.831169*	*700*	*318.8*	*75.77*	*-6.4083*	*-0.58461*
12	*6.387545*	*3.494723*	*77.24746*	*39.08661*	*196*	*3.193773*	*800*	*491.2*	*87.36*	*-2.93297*	*-0.52787*
13	*4.947016*	*1.563716*	*72.37097*	*66.29302*	*200*	*2.473508*	*700*	*375*	*84.73*	*-12.0507*	*-0.89039*
14	*2.419487*	*-4.68384*	*55.58932*	*89.50409*	*452*	*1.209744*	*700*	*372.8*	*60.03*	*-16.6719*	*-0.92397*
15	*11.82153*	*6.525379*	*85.97833*	*59.2449*	*224*	*5.910766*	*1300*	*1372.4*	*94.02*	*-2.41855*	*-1.58117*
16	*3.649818*	*0.055799*	*66.16757*	*80.20854*	*300*	*1.824909*	*800*	*18.2*	*73.10*	*-6.32155*	*-1.03733*
17	*4.146726*	*1.420089*	*68.79579*	*68.85274*	*280*	*2.073363*	*800*	*355*	*80.41*	*-11.8197*	*-0.76384*
18	*5.039032*	*0.981803*	*72.73795*	*79.80356*	*196*	*2.519516*	*700*	*209.6*	*83.88*	*-13.5008*	*-0.58171*
19	*8.963991*	*3.850675*	*82.38925*	*64.58558*	*168*	*4.481996*	*800*	*332.8*	*94.06*	*-26.9649*	*-1.17525*
20	*5.231146*	*1.134447*	*73.58166*	*87.9443*	*164*	*2.615573*	*700*	*90.6*	*85.38*	*-15.3024*	*-0.71418*
21	*9.188607*	*2.203046*	*82.76671*	*73.93715*	*152*	*4.594303*	*800*	*279.4*	*92.64*	*-17.2043*	*-0.90762*
22	*2.466101*	*-4.9515*	*56.98442*	*89.12745*	*400*	*1.233051*	*900*	*576.6*	*59.09*	*-1.20672*	*-0.44766*
23	*1.585347*	*-16.176*	*46.0778*	*82.46277*	*880*	*0.792673*	*1400*	*1780*	*47.32*	*-0.25994*	*-0.16828*
24	*3.009549*	*-0.14209*	*61.85026*	*89.59629*	*228*	*1.504775*	*700*	*131.4*	*69.32*	*-3.39846*	*-0.42198*
25	*8.978928*	*4.555617*	*82.56939*	*84.95066*	*184*	*4.489464*	*900*	*486.2*	*90.17*	*-5.596*	*-0.72042*
26	*1.659805*	*-8.82175*	*46.80013*	*93.55758*	*736*	*0.829902*	*800*	*325.2*	*52.14*	*-6.70827*	*-1.26021*
27	*8.759387*	*1.450331*	*82.20231*	*90.3585*	*164*	*4.379694*	*700*	*202.4*	*91.78*	*-13.5613*	*-1.15045*
28	*3.079192*	*-0.55207*	*62.85152*	*85.34956*	*216*	*1.539596*	*700*	*68*	*66.93*	*-3.14857*	*-0.45433*
29	*2.406033*	*-0.34397*	*57.87653*	*86.63869*	*148*	*1.203017*	*700*	*85.4*	*66.86*	*-11.6983*	*-0.37604*
30	*5.201444*	*0.800567*	*73.96085*	*85.01594*	*132*	*2.600722*	*600*	*84.6*	*84.83*	*-14.6053*	*-0.73596*
31	*3.234139*	*-0.90196*	*64.5911*	*91.48183*	*232*	*1.617069*	*700*	*222.6*	*72.69*	*-7.1367*	*-0.73219*
32	*6.930297*	*3.21826*	*78.89236*	*91.48183*	*232*	*3.465149*	*900*	*495*	*87.80*	*-11.0408*	*-1.10936*
33	*6.012953*	*0.910536*	*76.09818*	*91.56503*	*328*	*3.006477*	*1300*	*911.6*	*84.40*	*-1.93275*	*-1.01843*
34	*9.805284*	*1.832845*	*83.83947*	*90.3585*	*244*	*4.902642*	*900*	*1018.4*	*86.63*	*-2.42945*	*-0.65271*
35	*28.8012*	*6.562813*	*93.69789*	*33.62475*	*60*	*14.4006*	*800*	*686.4*	*100*	*-26.6602*	*-1.21839*
36	*6.812181*	*-0.26357*	*79.36104*	*53.26705*	*136*	*3.40609*	*600*	*283.6*	*86.16*	*-9.83783*	*-2.03088*
37	*3.97711*	*2.06396*	*68.0156*	*61.18079*	*276*	*1.988555*	*800*	*808.8*	*74.22*	*-2.56378*	*-0.61791*
38	*3.623101*	*4.378271*	*66.09482*	*67.6782*	*184*	*1.81155*	*600*	*339*	*83.78*	*-10.1716*	*-0.58323*
39	*7.759623*	*3.28692*	*80.46563*	*73.58844*	*180*	*3.879811*	*800*	*786.8*	*91.12*	*-13.222*	*-1.10434*
40	*4.650931*	*-1.8354*	*71.34211*	*92.54363*	*424*	*2.325465*	*1200*	*1734.8*	*77.00*	*-1.51294*	*-1.33599*

41	*3.981602*	*-7.60831*	*69.46494*	*69.16864*	*540*	*1.990801*	*600*	*2814.6*	*70.07*	*-1.44918*	*-1.13711*
42	*3.594752*	*-5.18995*	*67.82614*	*80.02649*	*436*	*1.797376*	*1400*	*2526.4*	*69.43*	*-0.67436*	*-0.91937*
43	*4.97188*	*-1.10511*	*76.3296*	*91.66677*	*332*	*2.48594*	*1300*	*1694*	*77.76*	*-1.47774*	*-1.0922*
44	*7.864045*	*-1.05623*	*81.44688*	*68.80009*	*212*	*3.932022*	*1100*	*1392.2*	*85.04*	*-2.28192*	*-1.01915*
45	*8.423334*	*2.467039*	*81.6067*	*39.3362*	*164*	*4.211667*	*900*	*787.8*	*92.09*	*-5.68991*	*-1.01915*
46	*2.576714*	*-11.3746*	*57.92496*	*86.19001*	*716*	*1.288357*	*1600*	*3962*	*60.34*	*-0.48316*	*-0.43885*
47	*4.204051*	*-2.35901*	*69.2058*	*85.29997*	*296*	*2.102025*	*1000*	*1398*	*74.64*	*-1.81581*	*-0.49289*
48	*1.509638*	*-15.2211*	*44.40503*	*96.18728*	*1036*	*0.754819*	*900*	*869.8*	*46.65*	*-4.44609*	*-1.09018*
49	*3.096923*	*-5.77784*	*62.52441*	*88.06921*	*464*	*1.548461*	*1100*	*1879*	*67.08*	*-1.64938*	*-0.9186*
50	*3.081487*	*-0.15144*	*62.40835*	*75.65167*	*244*	*1.540744*	*700*	*452.8*	*73.94*	*-8.18519*	*-0.78837*
51	*4.889864*	*1.569081*	*72.46982*	*63.93862*	*176*	*2.444932*	*700*	*515.6*	*83.77*	*-7.87544*	*-0.76593*
52	*4.490374*	*2.884332*	*71.19959*	*50.32713*	*168*	*2.245187*	*700*	*431.6*	*86.45*	*-13.7499*	*-0.71025*
53	*2.642915*	*-1.45065*	*59.08781*	*82.28113*	*268*	*1.321457*	*800*	*503.2*	*66.01*	*-1.92809*	*-0.4788*
54	*2.465733*	*0.096962*	*58.07686*	*78.00312*	*216*	*1.232866*	*700*	*364.6*	*68.96*	*-6.46581*	*-0.52254*
55	*4.984111*	*0.982773*	*73.30234*	*69.36965*	*220*	*2.492055*	*800*	*572*	*84.39*	*-7.36328*	*-0.59369*
56	*6.241282*	*3.452605*	*76.97549*	*75.91573*	*148*	*3.120641*	*700*	*489.6*	*90.03*	*-9.28484*	*-0.61989*
57	*7.515641*	*4.6285*	*80.07165*	*45.77916*	*132*	*3.75782*	*800*	*626.4*	*91.77*	*-9.13626*	*-1.16611*
58	*4.353831*	*0.560729*	*71.22257*	*84.23254*	*276*	*2.176915*	*800*	*646.8*	*73.61*	*-6.75321*	*-0.83144*
59	*2.894771*	*-1.43172*	*61.58972*	*67.97781*	*260*	*1.447385*	*800*	*2522*	*64.59*	*-1.8076*	*-0.30646*
60	*1.712373*	*-1.30179*	*65.10875*	*75.60447*	*276*	*0.856187*	*900*	*670.2*	*62.69*	*-6.13668*	*-0.59577*
61	*0.963854*	*-1.07061*	*37.53513*	*62.80618*	*192*	*0.481927*	*700*	*252.2*	*53.64*	*-3.78807*	*-0.12543*
62	*8.727678*	*2.707281*	*82.19765*	*75.24454*	*160*	*4.363839*	*800*	*584*	*91.78*	*-7.77403*	*-2.07316*
63	*5.270237*	*-0.22924*	*73.29641*	*71.42168*	*208*	*2.635118*	*800*	*513.2*	*79.97*	*-2.09398*	*-0.89804*
64	*7.309754*	*2.415851*	*79.75148*	*81.23477*	*232*	*3.654877*	*1000*	*894.8*	*86.58*	*-4.84826*	*-1.71268*
65	*5.46815*	*1.165931*	*74.9269*	*86.42873*	*204*	*2.734075*	*800*	*614.4*	*82.30*	*-4.43822*	*-0.801*
66	*6.453257*	*0.068769*	*77.75781*	*89.01747*	*216*	*3.226629*	*900*	*740.8*	*85.87*	*-2.9308*	*-0.97875*
67	*2.816673*	*-12.2121*	*61.5611*	*93.79093*	*700*	*1.408336*	*1000*	*2279*	*60.84*	*-1.59528*	*-1.54488*
68	*1.170599*	*-10.5065*	*47.72106*	*86.44844*	*868*	*0.5853*	*1000*	*2483.8*	*42.68*	*-0.43733*	*-0.30645*
69	*5.635565*	*1.664801*	*77.52974*	*86.59332*	*236*	*2.817783*	*1000*	*1831.8*	*83.47*	*-3.32751*	*-1.10872*
70	*3.870834*	*-1.82557*	*67.92858*	*91.21652*	*360*	*1.935417*	*1100*	*777.8*	*71.60*	*-1.32408*	*-0.90524*
71	*5.837365*	*1.34965*	*75.98408*	*94.10289*	*268*	*2.918683*	*1000*	*867.6*	*82.31*	*1.78957*	*1.09352*
72	*4.025534*	*-5.45566*	*72.80759*	*80.20854*	*400*	*2.012767*	*1800*	*1454.2*	*71.50*	*1.0561*	*0.81747*
73	*3.513019*	*0.140591*	*65.89456*	*92.31556*	*360*	*1.756509*	*1200*	*749*	*72.94*	*2.47736*	*0.59959*
74	*6.006258*	*2.562522*	*76.27891*	*91.48183*	*232*	*3.003129*	*1000*	*635.8*	*85.55*	*4.82708*	*0.77784*
75	*6.524715*	*0.972377*	*77.6455*	*80.5976*	*204*	*3.262358*	*1000*	*439.4*	*87.56*	*5.31605*	*1.18732*
76	*3.216616*	*1.976624*	*68.58458*	*89.21744*	*220*	*1.608308*	*900*	*9069.4*	*78.35*	*9.0009*	*0.75214*
77	*4.228432*	*0.840336*	*71.13731*	*74.71608*	*188*	*2.114216*	*800*	*9012.4*	*77.55*	*79761*	*0.71487*
78	*3.859482*	*0.731374*	*68.00757*	*90.11715*	*200*	*1.929741*	*800*	*9066.6*	*79.91*	*4.31221*	*0.53911*
79	*2.747267*	*0.802431*	*61.01531*	*76.97691*	*172*	*1.373633*	*700*	*8928.2*	*78.65*	*10.1928*	*0.45146*
80	*1.977675*	*1.312316*	*54.68232*	*89.01747*	*180*	*0.988838*	*700*	*9026.6*	*70.59*	*5.02992*	*.30598*
81	*5.360255*	*3.305896*	*74.38045*	*90.31118*	*204*	*2.680128*	*1000*	*9287.2*	*85.01*	*4.69273*	*0.67371*
82	*3.204986*	*-5.09431*	*63.4654*	*95.95276*	*488*	*1.602493*	*1200*	*9554.6*	*66.28*	*3.24015*	*0.82499*
83	*1.545261*	*-19.4412*	*45.99297*	*95.06179*	*1040*	*0.772631*	*2000*	*10164.4*	*45.11*	*0.08036*	*0.01497*
84	*18.99612*	*5.402678*	*90.8174*	*59.1401*	*68*	*9.498061*	*800*	*9056*	*100*	*19.9229*	*1.33863*
85	*19.62931*	*5.650834*	*91.05497*	*65.2971*	*80*	*9.814655*	*800*	*9072*	*100*	*1.33154*	*0.95888*
86	*4.904978*	*-2.353*	*72.39241*	*86.73663*	*328*	*2.452489*	*1400*	*9619.2*	*77.63*	*0.30205*	*0.39204*
Min	0.96	-19.44	37.53	4.3	60	0.48	500	18	24.90	-26	-2.07
Max	28.8	6.56	93.69	96.18	1040	14.4	2000	10164	227	-0.08	-0.01
Mean	5.48	-0.58	70.00	75.43	133.6	2.74	660	1885	105	-6.93	-0.82
STD	4.15	4.75	11.33	17.48	198.1	2.07	268.1	2930	36	6.03	0.39

Appendix 2: Standards use for the classification of ground and surface water quality for irrigation purposes.

Parameter	**Range**	**Class**	**No. of Samples**	
			Ground water	**Surface water**
SAR (Mandel and Shiftan, 1980)	0-10 10-18 18-26 >26	Use for all soil types Preferably use on coarse textured soil May produce harmful effect, good soil management is required Unsatisfactory	80 02	18
RSC (California Fertilizer Committee, 1975)	<1.250 1.25-20.5 >2.5	Safe Marginally suitable Unsuitable	55 12 15	15 2 1
%Na (Wilcox, 1955)	<20 20-40 40-60 60-80	Excellent – Good Permissible Doubtful Good Permissible Unsuitable	0 1 14 67	1 3 5 9
MR (Ayers and Westcot, 1985)	<50 >50	Suitable Unsuitable	11 75	01 13
TH (Vasanthavigar, 2010)	<75 75-150 150-300 >300	Soft Moderately Hard Very hard	02 09 53 18	0 02 0 16
KI (Sundary, 2009)	<1 >1	Suitable Unsuitable	09 73	05 13
EC (Vasanthanvigar, 2010)	<250 250-750 750-2000 2000-3000	Excellent Good Permissible Doubtful	0 32 50 0	01 02 15 0
TDS (Robinove et al., 1958)	<1000 1000-3000 3000-10000 >10000	Non saline Slightly saline Moderately saline Very saline	62 24	07 05 02

Appendix 3 (A): Physicochemical parameters at different location of the study area.

Ground Water

S.no	PH	EC	Hardness	TDS	Ca+2	Mg	Na	K	HCO3	Co3	Cl-	So4-	NO3	F
1	8.5	700	220	371.2	24.048	38.98358663	77	14	100	40	68.16	614.6164	45.21606	1.25
2	8.9	600	132	310.8	19.2384	20.46638298	200	22	160	40	25.56	258.9158	1.58788	0.6
3	8.8	700	188	502.2	72.144	1.949179331	275	25	210	40	56.8	736.9142	1.14704	0.7
4	8.9	700	160	451	12.8256	31.1868693	280	23	220	40	17.04	341.0512	2.09506	1
5	8.8	600	172	260.8	25.6512	26.31392097	131	21	100	60	17.04	191.2652	5.69668	0.59
6	8.7	700	192	372.2	17.6352	36.05981763	215	26	190	40	25.56	464.4189	14.93934	0.64
7	8.7	600	116	170	25.6512	12.66966565	385	10	40	40	34.08	753.868	2.57228	0.33
8	8.5	500	100	132.6	27.2544	7.796717325	70	7	30	20	22.72	604.1643	2.41178	0.27
9	8.5	700	188	289.8	20.8416	33.13604863	195	18	80	100	25.56	391.1719	0.6527	0.59
10	8.8	900	260	683	56.112	29.23768997	365	36	140	100	73.84	642.3515	0	0.41
11	8.4	700	212	318.8	46.4928	23.39015198	180	23	110	40	39.76	513.552	26.0438	1
12	8.3	800	196	491.2	48.096	18.51720365	290	31	210	120	119.28	706.134	13.9314	0.32
13	8.4	700	200	375	27.2544	32.16145897	230	23	220	60	28.4	425.2441	7.61198	0.44
14	8.7	700	452	372.8	19.2384	98.43355623	255	15	70	100	22.72	395.9453	8.10418	0.36
15	8.7	1300	224	1372.4	36.8736	32.16145897	615	39	430	120	284	386.9746	21.6782	0.45
16	8.6	800	300	18.2	24.048	58.47537994	255	31	130	120	56.8	277.4333	6.81376	0.56
17	8.9	800	280	355	35.2704	46.78030395	270	29	310	60	34.08	600.8723	34.04954	0.84
18	9.1	700	196	209.6	16.032	38.00899696	230	23	180	60	25.56	707.8623	12.51472	0.4
19	8.8	800	168	332.8	24.048	26.31392097	350	26	320	60	19.88	527.2138	3.0067	0.78
20	8.8	700	164	90.6	8.016	35.08522796	200	22	150	60	19.88	485.8169	3.04522	0.42
21	8.6	800	152	279.4	16.032	27.28851064	325	25	200	60	28.4	633.2985	11.6095	0.52
22	8.1	900	400	576.6	17.6352	86.73848024	230	29	30	80	170.4	474.1303	35.92846	0.25
23	7.8	1400	880	1780	62.5248	176.4007295	325	43	60	20	423.16	722.594	183.2	0.14
24	8.5	700	228	131.4	9.6192	49.70407295	160	21	70	100	59.64	489.6027	11.77428	0.22
25	9	900	184	486.2	11.2224	38.00899696	385	36	180	160	93.72	731.1532	14.50492	0.46
26	9.1	800	736	325.2	19.2384	167.6294225	285	29	210	80	59.64	282.3713	32.314	1.96
27	8.8	700	164	202.4	6.4128	36.05981763	335	31	210	40	36.92	526.2262	8.56	0.25
28	8.7	700	216	68	12.8256	44.83112462	155	26	30	100	62.48	431.3343	3.21	0.12
29	8.6	700	148	85.4	8.016	31.1868693	83	20	40	60	11.36	380.226	10.9	0.11
30	8.9	600	132	84.6	8.016	27.28851064	160	25	90	60	17.04	364.6713	4	0.13
31	8.2	700	232	222.6	8.016	51.65325228	175	38	110	60	36.92	385.987	14.9	0.3
32	9.1	900	232	495	8.016	51.65325228	375	50	280	100	51.12	525.8147	15.4	0.4
33	7.8	1300	328	911.6	11.2224	73.09422492	460	46	380	40	252.76	585.5645	10.7	0.3
34	8.7	900	244	1018.4	6.4128	36.05981763	375	37	30	140	176.08	641.5285	43	0
35	9.4	800	60	686.4	16.032	4.872948328	400	22	230	120	22.72	485.1585	6	0.7
36	8.9	600	136	283.6	25.6512	17.54261398	215	47	70	40	34.08	159	4.4	0.4
37	9	800	276	808.8	43.2864	40.93276596	255	30	100	180	116.44	352.7378	28.2	0.18
38	9	600	184	339	24.048	30.21227964	155	20	250	120	22.72	339.4875	15.4	0.32
39	9.4	800	180	786.8	19.2384	32.16145897	325	34	260	80	36.92	447.7943	39.3	0.12
40	9.1	1200	424	1734.8	12.8256	95.50978723	460	55	250	80	298.2	280.3138	70.8	0.11
41	8.7	600	540	2814.6	67.3344	90.63683891	500	121	80	60	355	478.3276	59.6	0.2
42	8.9	1400	436	2526.4	35.2704	84.78930091	365	107	100	60	389.08	250.88	57.5	0.08

43	9.1	1300	332	1694	11.2224	74.06881459	385	194	140	100	306.72	381.2959	35.95	0.05
44	9.1	1100	212	1392.2	27.2544	36.05981763	395	78	80	60	204.48	478.2453	69.3	0.26
45	9.3	900	164	787.8	40.08	15.59343465	320	29	230	60	76.68	637.4958	15.1915.6	0.47
46	8.9	1600	716	3962	40.08	150.0868085	430	50	110	40	471.44	586.9636	78.6	0.43
47	9	1000	296	1398	17.6352	61.39914894	290	34	100	60	167.56	715.2693	45.6	0.44
48	9.3	900	1036	869.8	16.032	242.6728267	365	36	110	120	107.92	380.33	40.4	0.55
49	9	1100	464	1879	22.4448	99.4081459	335	44	140	40	207.32	372.7367	95.3	0.47
50	9.2	700	244	452.8	24.048	44.83112462	175	23	170	60	31.24	330.55	23.6	0.57
51	9.2	700	176	515.6	25.6512	27.28851064	200	26	150	80	36.92	380.54	15.6	0.58
52	9.3	700	168	431.6	33.6672	20.46638298	175	30	220	80	19.88	394.84	6.42	0.52
53	9.1	800	268	503.2	19.2384	53.60243161	165	26	80	80	93.72	377.4278	15.7	0.57
54	9.2	700	216	364.6	19.2384	40.93276596	124	26	110	80	28.4	339.076	19.2	0.6
55	9.2	800	220	572	27.2544	37.03440729	255	44	250	40	51.12	800.2029	6.848	0.58
56	9.3	700	148	489.6	14.4288	27.28851064	215	26	190	100	34.08	540.0526	0	0.58
57	8.8	800	132	626.4	28.8576	14.61884498	230	27	160	140	36.92	167.2336	7.062	0.9
58	8.7	800	276	646.8	17.6352	56.52620061	280	65	50	160	62.48	424.3388	20.2	0.61
59	8.4	800	260	2522	33.6672	42.88194529	175	32	30	100	105.08	684.4891	7.11	0.5
60	8.2	900	276	670.2	27.2544	50.67866261	110	220	180	40	51.12	595.1936	81.3	0.5
61	8.4	700	192	252.2	28.8576	29.23768997	43	18	90	40	17.04	637.9896	4.9	0.5
62	8.5	800	160	584	16.032	29.23768997	325	32	200	80	59.64	173.4061	6.848	0.6
63	8.5	800	208	513.2	24.048	36.05981763	255	18	80	80	130.64	279.82	12.84	0.4
64	8.6	1000	232	894.8	17.6352	45.80571429	395	52	190	120	110.76	202.0465	46.438	0.5
65	9	800	204	614.4	11.2224	42.88194529	260	41	120	100	79.52	400.984	55.9	0.4
66	9.1	900	216	740.8	9.6192	46.78030395	325	46	190	40	136.32	476.2701	25.252	0.4
67	8.7	1000	700	2279	17.6352	159.8327052	460	107	40	40	306.72	350.984	25.038	0.4
68	8.4	1000	868	2483.8	43.2864	165.6802432	215	204	130	100	355	332.1628	261.7	0.4
69	9.2	1000	236	1831.8	12.8256	49.70407295	310	118	190	100	133.48	340.545	63.1	0.35
70	9.1	1100	360	777.8	12.8256	79.91635258	325	52	90	120	232.88	266.3228	11.4	0.47
71	9.2	1000	268	867.6	6.4128	61.39914894	365	52	170	120	215.84	280.66	15.2	0.43
72	8.6	1800	400	1454.2	32.064	77.96717325	375	210	80	40	369.2	543.8384	59.8	0.39
73	9.2	1200	360	749	11.2224	80.89094225	295	50	210	120	142	550.54	80.2	0.5
74	9.3	1000	232	635.8	8.016	51.65325228	325	39	240	100	90.88	593.7945	25.4	0.63
75	9.2	1000	204	439.4	16.032	39.95817629	310	34	230	40	79.52	380.54	56.5	0.3
76	9.3	900	220	9069.4	9.6192	47.75489362	165	100	230	80	34.08	427.137	5.4	0.32
77	9.2	800	188	9012.4	19.2384	34.1106383	185	52	80	100	48.28	354.845	28.6	0.39
78	9.2	800	200	9066.6	8.016	43.85653495	180	31	170	60	56.8	501.4539	33.1	0.3
79	9.1	700	172	8928.2	16.032	32.16145897	110	26	180	40	17.04	458.7402	6.3	0.5
80	9.2	700	180	9026.6	8.016	38.98358663	83	31	140	80	25.56	440.5	10	0.45
81	9.3	1000	204	9287.2	8.016	44.83112462	255	36	210	120	73.84	485.7346	35.7	0.45
82	9.1	1200	488	9554.6	8.016	114.0269909	365	52	90	100	142	536.1022	88.8	0.12
83	8.6	2000	1040	10164.4	20.8416	240.7236474	375	65	20	40	582.2	4182.3214	52	1.05
84	9.5	800	68	9056	11.2224	9.745896657	300	21	210	100	22.72	300.548	4.12	0.82
85	9.4	800	80	9072	11.2224	12.66966565	365	23	240	100	247.08	310.541	0	0.78
86	8.9	1400	328	9619.2	17.6352	69.19586626	375	44	140	60	468.6	341.14	74.9	0.47

Appendix 3 (B): Physicochemical parameters at different location of the study area.

Surface Water

S.no	PH	EC	Hardness	TDS	Ca+2	Mg	Na	k	HCO3	Co3	Cl-	So4-	NO3	F
1	8.4	1000	1020	952.4	60.9216	211.4859574	335	110	220	120	167.56	742.5929	66.3	0.47
2	8.9	1000	760	1154.6	38.4768	161.7818845	415	128	210	120	164.72	1057.555	67.1	0.39
3	8.9	1000	800	1075.6	43.2864	168.6040122	400	140	70	200	133.48	349.3635	62.9	0.57
4	8.8	1000	356	701.8	68.9376	44.83112462	325	99	70	180	147.68	525.4032	44.7	0.21
5	8.6	1000	376	1023.2	65.7312	51.65325228	220	108	110	180	142	173.4884	62.8	0.74
6	8.3	1000	384	987	80.16	44.83112462	255	107	170	140	153.36	429.3591	55.6	0.65
7	8.6	1000	388	988	57.7152	59.4499696	325	110	210	120	150.52	308.8719	67.6	0.61
8	8.2	1000	380	1052.2	60.9216	55.55161094	230	103	230	100	187.44	202.7872	87.1	0.66
9	7.9	1000	392	1054.2	51.3024	64.32291793	335	105	270	80	184.6	178.0149	44.3	0.8
10	8.2	1000	340	992.4	46.4928	54.57702128	325	105	230	120	147.68	200.812	36.38	0.7
11	8.1	1000	376	986.6	36.8736	69.19586626	330	100	280	60	147.68	235.4603	46.438	0.6
12	9.1	1100	1500	9530	256.512	209.5367781	300	120	290	60	161.88	446.321	62.6	0.55
13	9.1	1000	1540	9495.6	256.512	219.2826748	295	120	270	80	144.84	478.25	61.6	0.55
14	8.6	500	104	58.6	14.4288	16.56802432	50	10	70	100	8.52	318.7479	3.8	0.13

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