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Hydro Geochemistry Assessment of Shallow Aquifer in Muktainagar Area of Jalgaon District M.S. India

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Abstract:- ***Hydrochemical characteristics of shallow ground water samples were estimated for drinking and irrigation purposes collected from Muktainagar area in Jalgaon District, Maharashtra. Water samples were collected from 30 shallow aquifer twice a year for the study of pH, EC, TDS, total hardness, total alkalinity, calcium, magnesium, sodium, potassium, chloride, carbonate, bicarbonate, sulphate, phosphate and nitrate. General order of dominance of cations in the study area was found to be*** $Na^{+} > Mg^{++} > K^{+} > Ca^{++}$ ***while that of anions are*** $HCO_3^- > Cl^- > NO_3^{2-} > CO_3^{2-} > SO_4^{2-} > PO_4^{2-}$***.The nature of water in the study area is hard having high salinity with low alkalinity. Chloride, sulphate and calcium concentration were within permissible limits whereas magnesium was observed to be more in few aquifers. The high RSC, Mg% and PI for major samples justify the need of treatment of water samples before to be used for irrigation. Strong statistical correlation during regression analysis was observed between EC –TDS and EC-Cl. On the basis of CAI1& 2, 60% water samples in the study area shows positive cation anion exchange.***

Key words: - Ground water, drinking water, irrigation water, salinity, alkalinity, Muktainagar, Jalgaon area, Maharashtra.

I. INTRODUCTION

Water posses a significant role for its renewable form in nature. This makes it more valuable for any type of socio economic development. The development of any particular area solely depends on the availability of water. After third world war most of the countries are suffering from water, food, energy and health related problems. Crises of water management is seen everywhere. Proper water management has to be done as it directly affects the

agricultural aspects. Long term use of ground water can create a threat and will cause excessive withdrawal of ground water (USGS 2000).

The present study focuses on the groundwater demand in excess as compare to its recharge. Both rapid development in agricultural sector and increasing population growth have done adverse impact on the environment (Patil S.N. 2011)[1]. Sources of ground water contamination have been reported due to faulty well construction, lack of sanitation, improper waste disposal and lack of water sources protection informative measures. Being a rural area such problems arises where people are illiterate and their earning source is only agriculture. The present study takes into account the problems related to groundwater depletion, deterioration in quality and management.

II. DESCRIPTION OF THE STUDY AREA

The present study area is located towards the eastern part of Jalgaon city of Maharashtra State, India. It is located at 21°03'08"North latitude and 76°03'18"East longitude (fig 1). The area of Muktainagar Tehsil is of 63,392 hectares. The average annual rainfall is 750 mm/per annum. Rainfall of the study area is predominant in the monsoon season from June to September. The study area consists of alluvial plain of Tapti valley associated with Purna River flowing from north to south. The climate of the study area is characterized by hot summer and dry throughout the year. The mean minimum and maximum temperature lies between 10.8°C and 42.2°C.

Ground water from shallow aquifer was collected from 30 sample stations during May 2012 (pre monsoon) and Nov. 2012 (post monsoon) from Muktainagar area Jalgaon district. The water samples were collected in pre-cleaned polyethylene one litre bottles. The sample bottles were labeled, sealed and transported to the laboratory for further hydro chemical analysis. The analytical procedure and techniques followed by APHA (1995)[2].

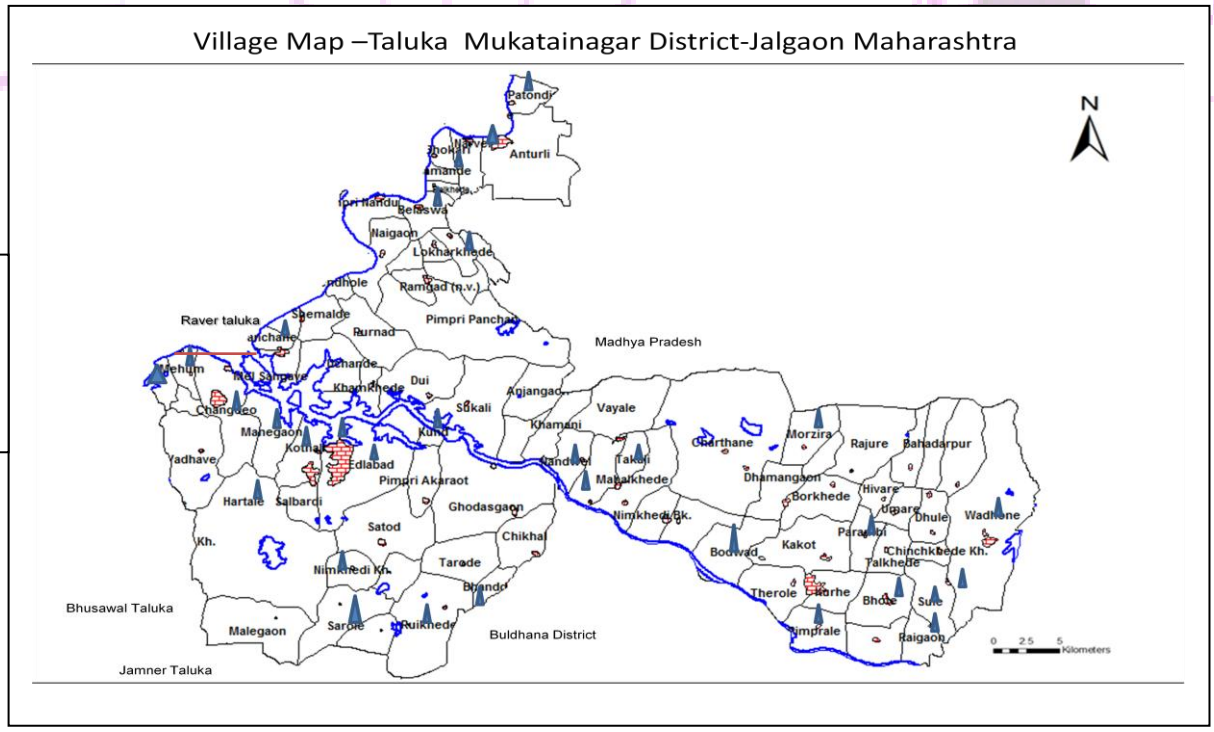


Fig 1 Location Map of the study area

III. MATERIAL AND METHODS

Estimation of pH, EC and TDS were measured digitally. The sodium and potassium were determined by using Flame photometer and titration methods was used for calcium, chloride, total alkalinity, carbonate, bicarbonate, total hardness while sulphate, phosphate, nitrate were analysis by Spectrophotometer. Further based on the physicochemical analysis, irrigation quality parameters like sodium absorption ratio (SAR), Kelley's ratio (KR), sodium percentage (Na %), residual sodium carbonate (RSC), Magnesium ratio (Mg %), corrosivity ratio, chloro alkaline indices are formulated as:-

$$SAR: - [Na / \{\sqrt{(Ca + Mg)/2}\}] \quad (1)$$

$$RSC = [(CO_3 + HCO_3) - (Ca + Mg)] \quad (2)$$

$$KR: - [Na / (Ca + Mg)] \quad (3)$$

$$Na\% = [(Na \times 100) / (Ca + Mg)] \quad (4)$$

$$MR = [(Mg \times 100) / (Ca + Mg)] \quad (5)$$

$$PI = [(Na + \sqrt{HCO_3}) / (Ca + Mg + Na)] \times 100 \quad (6)$$

$$CAI\text{–}I = [\{Cl - (Na + K)\} / Cl] \quad (7)$$

$$CAI\text{-}II = [Cl - (Na + K)] / [SO_4^{2-} + HCO_3^{-} + CO_3^{2-} + NO_3^{-}] \quad (8)$$

(Where all the ionic concentrations are expressed in meq/l).

IV. RESULT AND DISCUSSION

Drinking water quality parameters: - The quality of water used for drinking purposes depends upon the different chemical and biological parameters. In present study area the different parameters were studied, analyzed and compared with the guidelines suggested by Bureau of Indian standard (BIS) for drinking water quality (BIS 2012)[3] and World Health Organization (WHO1993). This was done to evaluate the suitability of the water quality for human consumption in the form of drinking (Table2). pH ranges from 7 to 8.2 in pre monsoon and 7 to 8.3 in post monsoon, whereas average is 7.4 and 7.5 in pre monsoon and post monsoon respectively. This shows that water is alkaline in nature throughout the year.

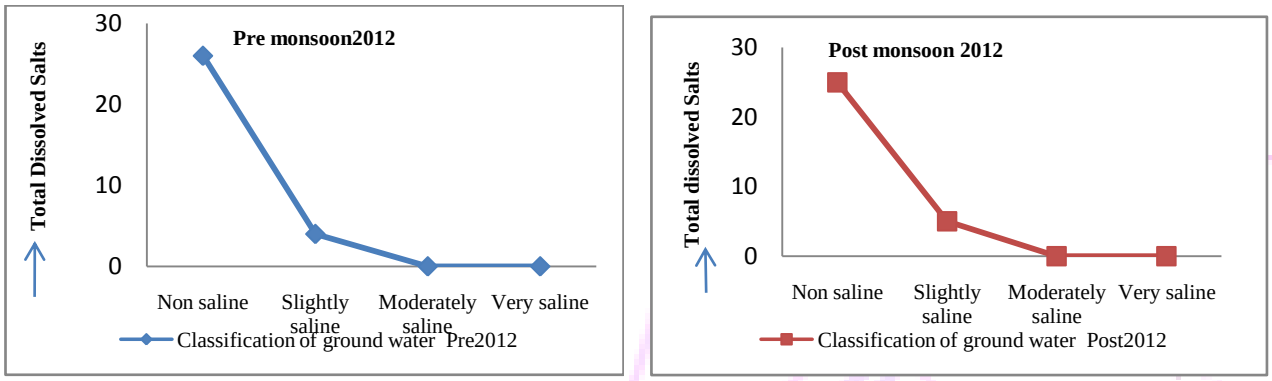


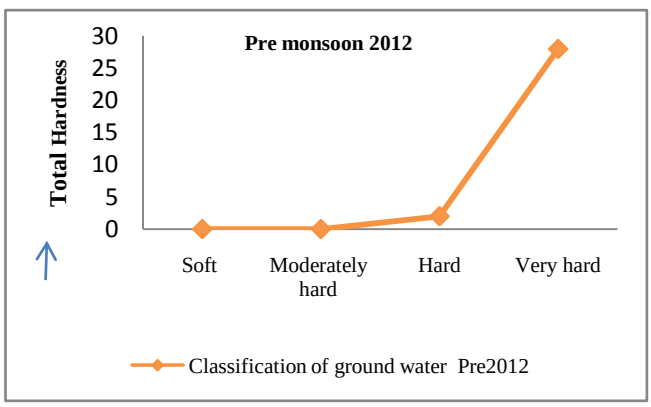
Fig 2: Graphical presentation of classification of water with TDS as per Rabinove (1958)

Table 1: Summary statistics of physicochemical parameters of shallow aquifer samples from muktainagar area.

Parameters	Pre monsoon 2012					Post monsoon 2012				
N=30	Max.	Min.	Avg.	SD	median	Max.	Min.	Avg	SD	median
pH	8.2	7.0	7.4	0.3	7.4	8.3	7.0	7.5	0.3	7.5
EC	3300.0	565.0	1114.4	592.8	950.0	3910.0	295.3	1096.5	781.4	900.2
TDS	2145.0	305.0	686.8	398.6	585.0	2768.0	235.5	721.7	549.2	621.2
Turb.	8.6	0.1	1.1	1.7	0.5	3.0	0.2	0.7	0.7	0.5
Total hardness	2267.5	109.0	586.2	532.0	347.0	1224.0	172.0	388.1	232.5	332.0
Total alkalinity	995.0	17.2	355.0	177.1	337.0	869.4	19.3	353.3	145.8	365.4
Ca^{2+}	51.2	8.8	32.4	13.2	31.6	312.6	19.3	67.8	54.3	53.3
Mg^{2+}	227.7	6.7	49.6	43.3	42.6	158.4	19.4	56.1	35.3	42.9
Na^{+}	364.0	10.6	70.5	73.6	55.9	456.1	19.8	83.3	87.7	53.4
K^{+}	158.4	0.1	6.6	28.7	0.9	159.9	0.4	7.0	28.9	1.2
Cl^{-}	471.4	1.2	113.2	114.7	83.7	471.9	2.0	104.4	110.9	52.0
SO_4^{2-}	67.9	8.1	31.8	16.8	30.9	143.0	8.3	42.7	35.2	26.3
CO_3^{2-}	96.0	9.6	41.4	22.1	40.7	136.1	13.2	40.9	28.2	33.2
HCO_3^{-}	846.0	76.3	368.0	170.6	344.8	830.1	117.9	407.3	142.1	379.1
NO_3^{-}	102.2	13.2	41.3	23.0	40.8	109.8	14.2	44.3	24.7	43.8
PO_4^{2-}	10.5	0.0	1.2	2.0	0.9	11.4	0.0	1.9	2.2	1.1

(All the parameters are expressed in ppm. Except EC in $\mu s/cm$ and pH. Here N= number of ground water samples.)

Total dissolved salts ranges from 305 to 2145 in pre monsoon and 235.5 to 2768 in post monsoon. As per BIS one sample from each season was above the permissible limit (2000ppm). According to Rabinove et.al (1958) [4]. TDS classification, water samples were categories as non saline (<1000ppm), slightly saline (1000 – 3000ppm), moderately saline (3000 – 10,000ppm),
very saline (>10,000ppm). The majority of water falls under non saline nature from fig 2 .The decrease in conductivity and TDS may be due to dilution of water due to rainfall in post monsoon or vice versa the rate of evaporation is more rapid due to high temperature during pre monsoon in summer. The above mentioned is clear with turbidity as it ranges more in post monsoon than pre monsoon. In pre **monsoon it ranges 0.1 to 8.6 and in post monsoon it ranges from 0.2 to 3.**



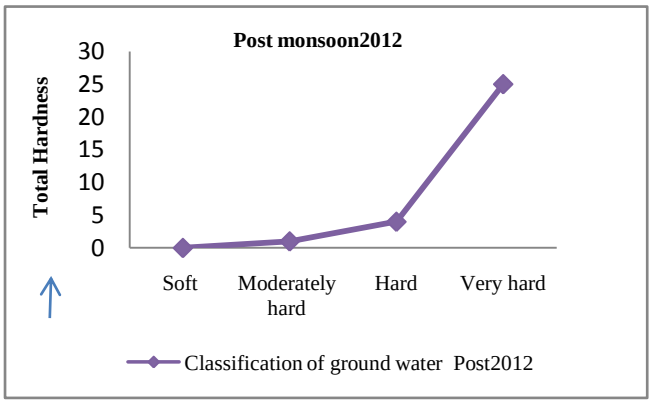


Fig 3: Graphical presentation according to Durfor and Becker's classification of water with Total Hardness.

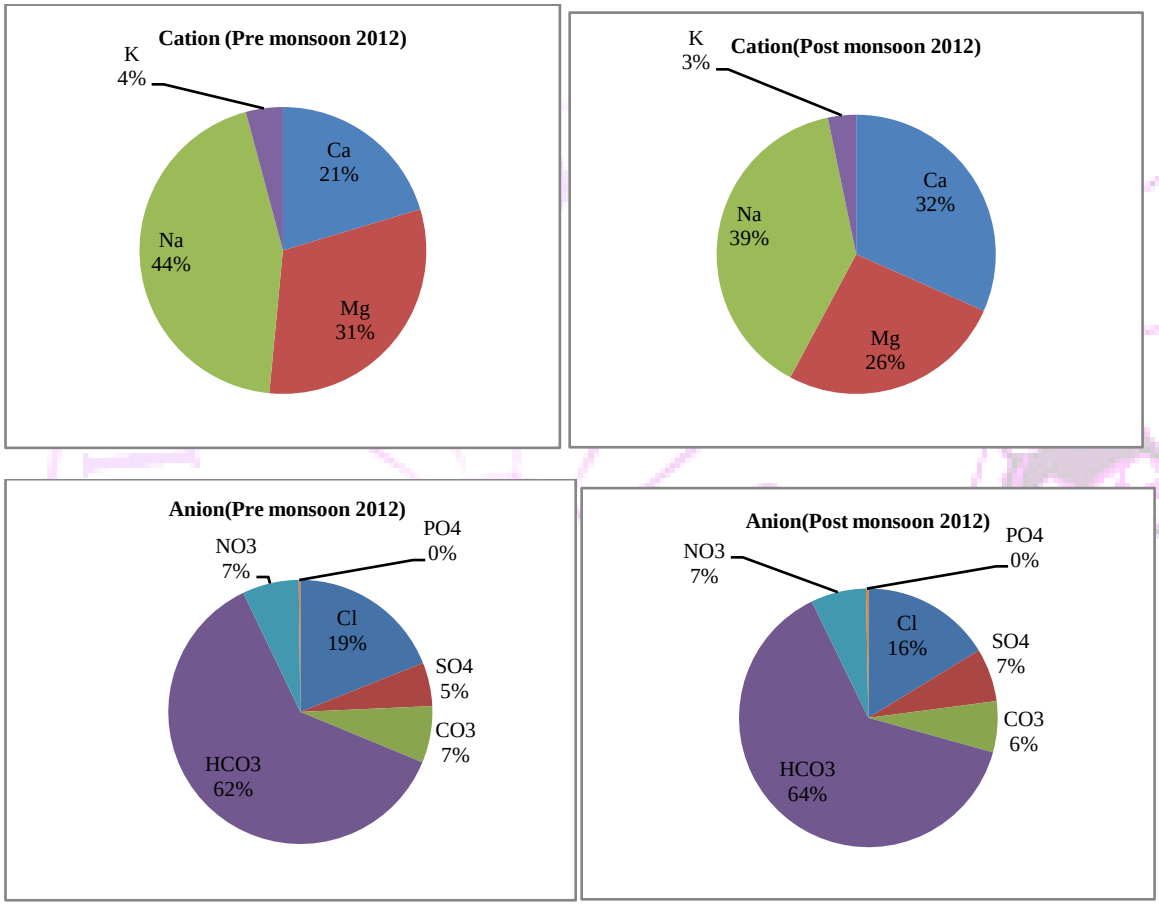


Fig-4: Pie chart of mean concentrations of cations and anions in (meq/l).

Total hardness varies from 109 to 2267.5 and 172 to 1224 in pre monsoon and post monsoon respectively. According to BIS 10 sample from pre monsoon and 3 samples from post monsoon were above permissible limit (600ppm). As per the classification of Durfor and Becker's of total hardness, the water samples were classified as soft (<60ppm), moderately hard (61–120ppm), hard (121– 180ppm) and very hard (>180ppm). From the graphical presentation in fig 3, it is clear that 83% and 93% water are very hard in both the season where as 13% and 7% are

hard in nature in both the season. Total alkalinity varies from 17.2 to 995 and 19.3 to 869.4 in pre monsoon and post monsoon. Average alkalinity varies 355ppm and 353.3ppm in pre monsoon and post monsoon respectively. As per BIS one sample from each season was above permissible limit (600ppm).

Major ions: - Dominance of cations and anions were observed from Fig 4 as $Na^+ > Mg^{++} > K^+ > Ca^{++}$ and $HCO_3^- > Cl^- > CO_3^{2-} > NO_3- > SO_4^{2-} > PO_4^{2-}$ in pre monsoon whereas in post monsoon it varies as $Na^+ > Ca^{++} > Mg^{++} > K^+$ and $HCO3^- > Cl^- > SO_4^{2-} > CO_3^{2-} > NO_3^{2-} > PO_4^{2-}$.

The abundance of sodium is observed in the both the season. Calcium was observed as second abundance after rainy season it may be due to dilution of rock salt. Calcium ranges from 8.8 to 51.2 and 19.3 to 312.6 with their average 32.4 and 67.8 in pre monsoon and post monsoon respectively. One sample exceeds the permissible limit in post monsoon. Mg ranges from 6.7 to 227.7 and 19.4 to 158.4 with their average 49.6 and 56.One in Pre monsoon and post monsoon. Two and three samples were found to exceed the permissible limit in the consecutive season.

Potassium varies from 0.1 to 158.4 and 0.4 to 159.9 with average of 6.6 and 7 in the consecutive season. One sample from each season exceeds the permissible limit.

Chloride varies from1.2 to 471.4 and 2 to 471.9 with 113.2 and 104.4 averages in pre monsoon and post monsoon respectively. Sulphate varies from 8.1 to 67.9 and 8.3 to 143 with their average 31.8 and 42.7 in pre monsoon and post monsoon. All the water samples were with the limits in case of chloride and sulphate.

Carbonate varies 9.6 to 96 and 13.2 to 136 with their average 41.4 and 40.9. Whereas, bicarbonate ranges from 76.3 to 846 and 117.9 to 830. Bicarbonate was observed as most abundance in both the season. Nitrate ranges from 13.2 to 102.2 and 14.2 to 109.8 with their average 41.3 and 44.3.One sample from each season is above the permissible limit. Phosphate ranges from 0 to 10.5 and 0 to 11.4.

Table 2: Hydrochemical parameters showing the number of water samples exceeding the permissible limit.

Parameters N=30	Highest desirable limit	Permissible limit	No. of sample above limit	
			Pre monsoon 2012	Post monsoon 2012
pH	6.5-8.5	------	00	00
EC	1400	-------	07	06
Turbidity	5	10	00	00
TDS	500	2000	01	01
Total hardness	300	600	10	03
Total alkalinity	200	600	01	01
Ca^{2+}	75	200	00	01
Mg^{2+}	30	100	02	03
K^{+}	10	10	01	01
Cl^{-}	250	1000	00	00
SO_4^{2-}	200	400	00	00
NO_3^{2-}	45	100	01	01

Irrigation water quality:-

Salinity and alkalinity hazard: - Salinity is referred as the total amount of dissolved inorganic solid material. Whereas Salinization is the increase in TDS and overall chemical contents present in the water. Presence of excessive chemical ions in water such as sodium, bicarbonate used for irrigation may affect the soil fertility and crop productivity (R. Rajesh et al...2015)[5].

Electrical Conductivity plays an important role for water quality used for irrigation. EC ranges from 565 to 3300 in pre monsoon and 295.3 to 3910 in post monsoon where as the average value is 1114.4 and 1096.5 in pre monsoon and post monsoon. EC plays an important role in water quality in agriculture and drinking aspects. As per BIS 7 samples from pre monsoon and 6 samples from post monsoon were above permissible limit (1400µS/cm).

According to Mandal et al. (2005)[6] EC classification, water samples were categorized as fresh (<1500µS/cm), brackish (1500-3000) and saline (>3000µS/cm). Fig 4 shows nearly 80% falls under fresh categorize, 16% falls under brackish water and only 1sample is found to be saline nature in both the season.

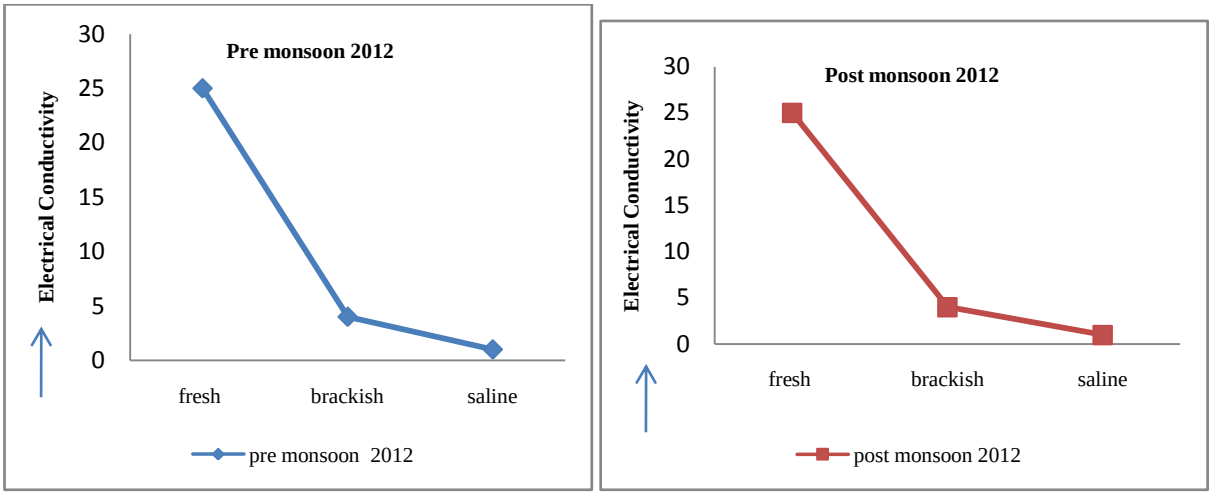


Fig4: Graphical presentation according to Mandal (2005) classification of water with Electrical conductivity.

Table: 3 Statistical summaries of different irrigation parameters

Irrigation Parameters	Pre monsoon 2012					Post monsoon 2012				
	Max	Min	Avg	SD	median	Max	Min	Avg	SD	median
SAR	17.3	1.9	4.7	3.4	3.7	23.2	2.1	5.6	4.3	4.4
RSC	15.0	-4.0	3.5	3.9	3.0	12.7	-5.2	1.6	2.9	1.6
KR	3.8	0.1	0.7	0.7	0.4	3.2	0.1	0.5	0.6	0.3
Na%	377.4	7.6	66.7	73.2	43.5	320.5	15.0	51.1	57.3	33.5
MR	90.3	33.2	66.2	13.7	64.7	80.8	36.1	57.5	12.7	57.1
PI	110.7	36.0	66.8	19.5	64.5	90.4	29.8	56.3	14.7	57.4
CAI1	0.7	-109.0	-3.8	19.9	0.2	0.6	-75.9	-3.0	13.8	-0.4
CAI2	15.7	-16.7	6.3	6.0	7.6	0.4	-0.7	-0.1	0.3	-0.1

Classification of water quality based on EC (Raghunath1987)[7] is given as 8 to 10 % sample are good, 20 - 17 % samples are medium whereas 2-3 % water samples are bad for irrigation and cannot used without treatment. Excessive salinity reduces osmotic pressure and interferes with adsorption of nutrients and water from the soil (Saleh et al. 1999)[8]. Water containing high sodium increases the hardness and reduces the soil permeability (Tijani 1994)[9].

Table4:-Classification of water based on irrigation strategy of Muktainagar area

Classification	Category	Ranges	No of samples		%of the sample	
			S1	S2	S1	S2
Electrical conductivity (EC)	Excellent	<250	00	00	00	00
	Good	250 -750	08	10	26	33
	Permissible	750 -2250	20	17	67	57
(Wilcox 1955)	Doubtful	2250 -4000	02	03	7	10
	unsuitable	>4000	00	00	00	00
Sodium absorption Ratio (SAR)	Excellent	<10	27	27	90	90
(Richard 1954)	Good	10 -18	03	02	10	6
	Fair	18 -26	00	01	00	3
	Poor	>26	00	00	00	00
Residual sodium carbonate	Suitable	<1.25	07	13	23	43
(Richard 1954)	marginal	1.25 – 2.50	04	09	13	30
	unsuitable	>2.50	19	08	63	26
Kelley's Ratio	suitable	<1	24	27	80	90
(Kelley 1940)	unsuitable	>1	06	03	20	10
Sodium % (Na%)	Excellent	0 - 20	06	05	20	17
	Good	20 – 40	07	12	23	40
(Doneen 1962)	Permissible	40 – 60	07	08	23	27
	Doubtful	60 – 80	03	01	10	3
	unsuitable	>80	07	04	23	13
Magnesium %	suitable	<50	03	10	10	33
(Pandian & Sankar 2007)	unsuitable	>50	27	20	90	67
Permeability Index (Doneen 1964)	Class I	>75	10	02	33	7
	Class II	25 - 75	20	28	67	93
Chloro- Alkaline Indices (CAI)	Base Exchange Reactions	Negative value	12	22	40	73
(Schoeller 1967)	Cation –Anion Reactions	Positive value	18	08	60	27

Sodium absorption ratio (SAR) which determines the sodium or alkalinity hazards present in the water used for irrigation. SAR ranges from 1.9 to 17.3 and 23.2 to 2.1 with average 4.7. It helps to indicate the extent of water entering into cations exchange reaction with soil (Raju 2007)[10]. According to SAR (Raghunath 1987)[7],the SAR value was classified as (<10 as excellent; between 10-18 as good; 18-26 as fair; and < 26 as of poor quality).the tabularized classification and comparison done in table 4 shows that almost 90% water sample are excellent for irrigation in both season, nearly 10% and 6% are in good condition whereas 3% are in fair condition in post monsoon.SAR is an important parameter for determining suitability of ground water for irrigation as it is a measure of alkali /sodium hazards to crop (Richard 1954)[11]. If the SAR value is more than 12, then it threats for the survival of vegetation by increasing soil swelling and reducing soil permeability (Kuipers et al., 2004)[12].

Residual Sodium Carbonate (RSC) was calculated as per (Raghunath, 1987 & Eaton 1950) [7, 13] i.e. the total amount of carbonate and bicarbonate over calcium and magnesium shows unfavorable effect on agricultural practices. Lloyd and Heathcote (1985)[14] have classified irrigation water based on RSC (< 1.25 as suitable, between 1.25 to2.5 marginal and >2.5 as not suitable). In the present study area 23% and 43% are suitable, 13% and 30% are in the marginal position and 63% and 26% are unsuitable for irrigation in the pre monsoon and post monsoon respectively. Majority of water samples should be treated before it is used in the field.

Kelly's ratio (KR):- Kelley et.al. (1940) have suggested that sodium problem present in irrigational water can be worked out with the help of Kelley's ratio. Ground water having Kelley's ratio more than one is generally considered as unfit for irrigation. It varies from 0.1 to 3.8 to 0.1 to 3.2. About 20% and 10% are not fit for irrigation in pre monsoon and post monsoon.

Sodium Percentage (Na %):- Sodium concentration is an important feature for describing type of irrigation. The sodium percentage is calculated according to Doneen (1962)[15].High sodium concentration in water tends to be absorbed by clay particles and dissipating magnesium and calcium ions. This exchange process of sodium with Ca^{2+} and Mg^{2+} leads to reduces soil permeability and subsequently results in poor internal draining (Tiri and Boudoukha, 2010)[16]. Sodium is an important ion used for the classification of irrigation water as it studies the reaction with soil and reduces its permeability (Vasanthavigar et al., 2010)[17]. Here it varies from 7.6 to 377.4 and 15 to 320. It is found that water having more than 60% sodium is unfit for irrigation. 33% and 16% samples are having sodium percentage more than 60% in both the season.

Magnesium Ratio is the concentration ratio of magnesium if found less than 50, then it is suitable for irrigation purpose (Pandian & Sankar 2007)[18]. In present study area 90% of pre monsoon and 67% of post monsoon are having magnesium percentage is more than 50, so they are not fit for irrigation.

	pH	EC	TDS	TH	TA	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	CO_3^{2-}	HCO_3^{-}	NO_3^{-}	PO_4
pH	1														
EC	0.0	1													
TDS	-0.2	0.9	1												
TH	0.3	0.4	0.4	1											
TA	0.0	0.5	0.5	0.3	1										
Ca^{2+}	0.0	0.5	0.3	0.4	0.3	1									
Mg^{2+}	-0.1	0.7	0.7	0.3	0.3	0.3	1								
Na^{+}	-0.2	0.6	0.6	0.0	0.6	0.1	0.3	1							
K^{+}	0.1	0.4	0.4	0.6	0.1	0.2	0.0	0.1	1						
Cl^{-}	-0.1	0.9	0.8	0.5	0.4	0.4	0.6	0.6	0.6	1					
SO_4^{2-}	-0.2	0.6	0.6	0.2	0.4	0.3	0.7	0.5	0.2	0.7	1				
CO_3^{2-}	-0.3	0.4	0.5	-0.2	0.4	0.1	0.2	0.6	0.2	0.4	0.3	1			
HCO_3^{-}	0.1	0.4	0.4	0.3	0.8	0.3	0.3	0.5	0.2	0.4	0.4	0.2	1		
NO_3^{-}	-0.4	0.1	0.3	-0.4	0.0	-0.3	0.0	0.2	0.0	0.1	0.1	0.6	-0.2	1	
PO_4	0.1	0.3	0.4	0.4	0.2	0.1	-0.2	0.2	0.9	0.4	0.0	0.4	0.1	0.3	1

Table 5: Correlation matrix (Spearman's Rank Correlation Coefficient) for pre monsoon 2012

Permeability Index (PI) is helpful to measure the soil permeability, utilized for assessing the suitability of water used for irrigation. Doneen (1964)[15] has evolved a formula for calculating permeability index. PI varies from 36 to 110.7 and 29.8 to 90.4 in the consecutive season. In present study area, 67 and 93% samples are in class II showing suitability for irrigation and 33 and 7% samples are in class in both the season showing unsuitability for irrigation.

Indices of Base Exchange: - Schoeller (1965, 1977)[19] has evolved a formula, to study the changes taking place in the composition of ground water along its flow path in the aquifer. He suggested Chloro-Alkaline Indices (CAI) I & II to study the ion exchange and host environment.

If there is exchange taking place of Na and K from water with Magnesium and Calcium in the rock, the exchange is direct and the indices are positive. If the exchange is reverse then the exchange process is indirect and the indices will be negative (Nagaraju et al., 2006)[20]. CAI –I varies from -109 to 0.7 and -75.9 to 0.6 and CAI-II from -16.7 to15.7 and -07 to 0.4 in both the season. Calculations of CAI-I & II shows 60 and 27 % samples are having positive value proving cation- anion exchange reactions where as 40 and 73% shows negative value proving base exchange reactions.

Correlation Matrix:-

It is a bivariate correlation method which helps to determine the degree of relationship between two variables. Spearman's rank correlation coefficient is denoted by ρ (rho) and its value always lies between -1 to +1. A positive ρ correspond to an increasing while negative ρ corresponds to decreasing trend between two different water quality parameters (Srivastava, 2008)[21].

The table5 shows statistical regression analysis between EC-TDS, TDS-Cl, with strong positive relation with r^2 value of 0.90, 0.82 in pre monsoon. Similarly in post monsoon (table 6) strong statistical regression analysis was between EC- TDS, EC-Cl, EC-SO_4, TDS –Cl, TDS- SO_4, TH- Cl, TA-HCO_3 with positive r_2 value as 0.98, 0.94, 0.91, 0.93, 0.88, 0.90, 0.92 respectively. In pre monsoon, pH shows negative correlation with TDS, Mg, Na, Cl, sulphate, nitrate. Other parameters show positive correlation among themselves except total hardness and carbonate, magnesium and phosphate, calcium and nitrate. In post monsoon, pH showed same negative correlation as in pre monsoon rather than total hardness & carbonate others showed positive correlation.

	pH	EC	TDS	TH	TA	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	CO_3^{2-}	HCO_3^{-}	NO_3^{-}	PO_4
pH	1														
EC	0.0	1													
TDS	0.0	1.0	1												
TH	-0.1	0.9	0.9	1											
TA	0.1	0.6	0.5	0.3	1										
Ca^{2+}	0.0	0.8	0.8	0.9	0.2	1									
Mg^{2+}	-0.3	0.7	0.7	0.8	0.4	0.5	1								
Na^{+}	-0.1	0.7	0.6	0.2	0.6	0.2	0.4	1							
K^{+}	0.1	0.7	0.7	0.7	0.1	0.8	0.3	0.2	1						
Cl^{-}	-0.2	0.9	0.9	0.9	0.4	0.8	0.8	0.5	0.6	1					
SO_4^{2-}	-0.1	0.9	0.9	0.8	0.5	0.8	0.7	0.6	0.5	0.9	1				
CO_3^{2-}	-0.1	0.4	0.3	0.1	0.5	-0.1	0.2	0.8	0.0	0.3	0.3	1			
HCO_3^{-}	0.2	0.5	0.5	0.4	0.9	0.3	0.3	0.5	0.2	0.3	0.4	0.2	1		
NO_3^{-}	-0.3	0.1	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.2	0.1	0.5	-0.2	1	
PO_4	0.2	0.6	0.6	0.5	0.3	0.7	0.1	0.3	0.8	0.5	0.4	0.2	0.3	0.2	1

Table 6: Correlation matrix (Spearman's Rank Correlation Coefficient) for post monsoon 2012

V. Conclusion

The hydrogeochemical study of shallow ground water samples of Muktainagar area shows the following conclusion:- The abundance of the major ions was in the order of cations are $Na^{+} > Mg^{++} > K^{+} > Ca^{++}$ and anions are $HCO3^{-} > Cl^{-} > NO_3^{2-} > CO_3^{2-} > SO_4^{2-} > PO_4^{2-}$.The water samples were very hard to hard and approximately 33 and 10% crosses the permissible limit of BIS. Concentration of Calcium, Chloride ion and sulphate ions were in the permissible limit. Magnesium concentration was more at 2-3 sampling stations. TDS, total alkalinity, potassium, nitrate concentration were increased in one or two sampling stations.

High salinity was recorded as brackish and saline nature which is unfit for irrigation. It was recorded as 7 – 10 % was in doubtful condition. Increased SAR value more than 12 was observed at few places. Major samples showed unsuitable RSC values. Kelley's ratio and sodium percentage was found to be more in 20 to 23% samples.90% samples consists increased Mg% which is very harmful for agriculture. Permeability index was also observed more in 33% samples. As per CAI1 & II 60% samples showed positive cation anion exchange and 40% showed negative bases exchange reactions.

VI. References

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