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Physicochemical and Biochemical Characterization of Groundwater for Assessment of Potentials for End user Applications

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Abstract

Groundwater is presently under threat with deterioration of its quality due to anthropogenic activities. In the present research work Groundwater samples are collected from nine locations in Jaggayyapeta mandal of Krishna District, Andhra Pradesh, India duering pre and post monsoon seasons and analyzed for physicochemical parameters like pH, EC, TDS, TH, TA, DO, CO_3^{2-}, HCO_3^- ,Cl^-, SO_4^{2-}, PO_4^{3-}, NO_3^-, Ca^{2+}, Mg^{2+}, Na^+ and K^+ to evaluate the chemical contamination. Irrigation parameters %Na, RSC, SAR and KR are determined to assess the suitability of ground waters for irrigation purposes and the lower values revealed the suitability of waters for irrigation. The ground waters are analyzed for bacterial species and the presence of pathogenic bacteria *E.Coli, Psuedomonas, Proteus, Enterobacter and Klebsiella* confirmed the bacterial contamination of waters. The research results revealed that the waters are chemically and microbially contaminated. The waters are to be treated suitably considering the waters for applications.

Key Words: Groundwater, contamination, irrigation, bacteria

1. Introduction

The availability of water through surface and groundwater resources has become critical day to day. Only 1% part is available on land for drinking, agriculture, domestic power generation, industrial consummation, transportation and waste disposal[1]. The utilizable water resource in India is not enough to irrigate the cultivatable area. Hence, efforts are needed to maximize the chances of water for irrigation in agriculture[2]. The water quality is a consequence of the natural, physical and chemical state of the water as well as any alteration that might have accrued as a consequence of anthropogenic activity[3]. Irrigation is necessary for agricultural production in infertile and semiarid regions where rainfall is not sufficient to uphold crop growth. Irrigated agriculture consumes 60–80 % of the total water usage and contributes nearly 38 % of the global food production. It has played a major role in generating employment opportunities in the rural areas and providing food for low prices for downtrodden people in the urban area[4]. Natural groundwater is usually of good quality, but this can deteriorate due to inadequate source protection and poor resource management[5].

Subsurface and surface waters can be contaminated by several sources and in farming areas, the routine application of agricultural fertilizers is the major source[6,7]. In urban areas, the careless disposal of industrial effluents and other wastes may contribute greatly to the poor quality of the water[7-10]. The addition of pollutants and nutrients through the agency sewage, industrial effluents, agricultural runoff etc., in to the water bodies brings about a series of changes in the physicochemical and characteristics of water[11]. The effect of water pollution causes concern on people and to animals, fish, and birds. Polluted waste is unsuitable for drinking, recreation, agriculture, and industry. Contaminated water destroys aquatic life and reduces its reproductive ability and also a hazard to human health. Over pumping of ground water for aquaculture and agricultural activity lowered the ground water level and land to subside below sea level in some coastal regions[12]. Excessive irrigation water moves over or below the land's surface, and can pick up and carry away natural and man-made pollutants. These pollutants can end up in surface waters or move through the soil to groundwater resources impacting water quality. Pathogens, or disease causing organisms, include viruses, parasites, and protozoa[13].

The variation of RSC was drawn using[14] as good, medium and bad categories in 93% of the groundwater samples of the study area fall in good category, 3.5% falls in medium category and 3.5% in the bad category. Salinity of groundwater and SAR determines its utility for agricultural purposes. Salinity originates in groundwater due to weathering of rocks and leaching from top soil, anthropogenic sources along with minor influence on climate. The level of Na and HCO_3^- in irrigation[15,16]. Sodium percentage Na%[17] classification of groundwater to assess its suitability for agriculture purpose[18].

The pathogenic microorganisms comes from the faeces of human and warm blooded animals which brought to the river water through various ways like the release of effluent from waste water and house drainage, surface runoff[19]. Microbial contamination of water due to pathogenic organisms is another most important problem for the water quality management and another important factor for water pollution for water.

2. Materials and Methods

The sample bottle made of Polythene is used to collected the samples. Nine groundwater samples are collected from Jaggayyapeta mandal of Krishna District of Andhra Pradesh [20]. The details of the sampling locations with sampling code are presented in Table-1.

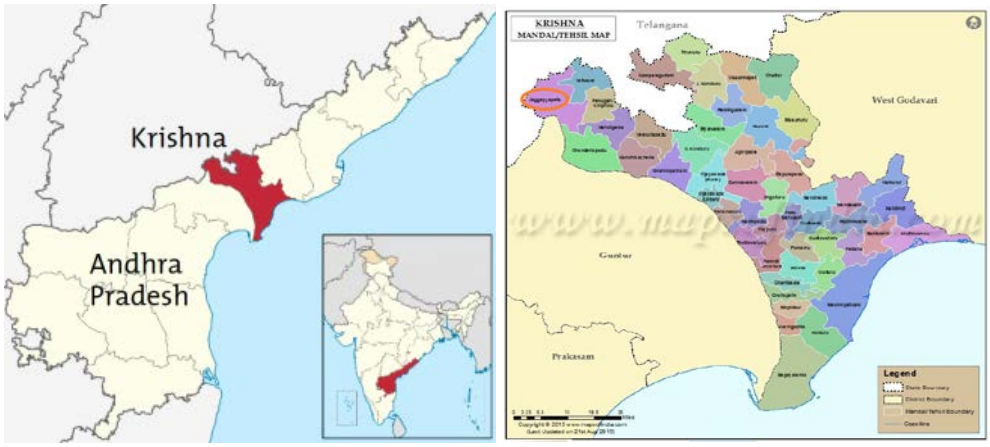


Fig-1: Study Area Map (source: https://krishna.ap.gov.in/district-profile/) [20]

Table-1: Sampling location details in Jaggayyapeta

Sample Code	Sample Location	GPS Coordinate	
		Latitude	Longitude
J-1	Pochampalli	16.83520	80.18343
J-2	Vedadri	16.81717	80.12764
J-3	Jayanthipuram	16.85747	80.12019
J-4	Mukteswarapuram (Muktyala)	16.82084	80.07351
J-5	Balusupadu	16.92350	80.04490
J-6	Takkellapadu	16.95954	80.09181
J-7	Gandrai	16.97127	80.10936
J-8	Malkapuram	16.99389	80.14803
J-9	Chilakallu	16.89524	80.14076

The samples are collected and preserved for analysis as per the standard procedures[21]. The measured parameters include – pH, Electrical conductivity (EC), total solids(TDS); anionic species like – Chloride, Sulphate, Phosphate and fluoride; Carbonate and bicarbonate content; total hardness as well as Calcium and Magnesium hardness, concentrations of Calcium, Magnesium, Sodium and Potassium as per Standard analytical procedures[21]. The determination of irrigation parameters viz., Percent Sodium, Sodium Adsorption Ratio (SAR), Kelly's Ratio (KR), Magnesium Hazard (MH) and Residual Sodium Carbonate (RSC) are carried out by following formulae.

Residual Sodium Carbonate (RSC): RSC = $(CO_3^{-2} + HCO_3^{-})-(Ca^{+2}+Mg^{+2})$

Percent sodium (%Na): $$\%Sodium(me/l) = \frac{\text{Na } X100}{Na + K + Ca + Mg}$$

Sodium Adsorption Ratio (SAR): $$SAR(me/l) = \frac{Na}{\sqrt{(Ca + Mg)/2}}$$

Kelly's Ratio (KR): $$Kelly'sRatio = \frac{Na}{(Ca + Mg)}$$

Magnesium Hazard (MH): $$MH = \frac{Mg^{+2}}{(Ca^{+2} + Mg^{+2})} \times 100$$

Microbial Analysis: In this part the details of experimental methodology employed to characterize and to identify the bacterial species in representative subsurface water samples near nonpoint sources Viz., Agricultural runoff, domestic sewage, irrigation return flows, Industrial effluents and brackish waters are characterized by following the standard procedures[22].

3. Results and Discussions:

Table-2: Details of Physicochemical Parameters

Sample Code	pH		TDS (ppm)		EC (µmhos/cm)		Salinity (ppm)		Temp. (°C)		DO (ppm)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
J-1	7.45	7.32	714	639	1005	900	503	450	30.2	28.5	0.99	1.15
J-2	7.64	7.31	1108	1015	1560	1430	780	715	30.4	28.1	2.41	3.23
J-3	7.81	7.75	781	675	1100	950	550	475	30.6	27.5	1.98	3.42
J-4	7.32	7.12	1274	1193	1795	1680	898	840	31.5	30.1	1.06	1.55
J-5	7.12	6.9	1377	1292	1940	1820	970	910	30.9	30.0	0.8	0.99
J-6	7.45	7.13	1477	1353	2080	1905	1040	953	30.7	29.1	1.56	1.67
J-7	7.62	7.21	1413	1328	1990	1870	995	935	30.6	28.9	1.08	1.26
J-8	7.08	6.92	1576	1345	2220	1895	1110	948	31.5	27.6	1.07	1.04
J-9	7.43	7.11	1747	1466	2460	2065	1230	1033	31.4	28.0	1.53	1.49

Table-3: Details of Physicochemical Parameters

Sample Code	Floride (ppm)		Chloride (ppm)		Nitrate (ppm)		Sulphate (ppm)		Phosphate (ppm)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
J-1	2.63	2.41	160	142	20.41	17.1	48.4	47.1	0.024	0.018
J-2	0.92	0.88	184	168	55.12	51.2	125.6	120.3	0.011	0.003
J-3	0.32	1.05	210	195	20.35	18.5	46.1	43.6	0.009	0.004
J-4	0.47	0.21	260	248	44.62	40.2	69.8	67.2	0.016	0.008
J-5	0.85	0.75	340	327	39.17	37.81	70.5	65.4	0.003	BDL
J-6	1.84	1.5	455	428	39.24	33.14	76.4	69.8	BDL	BDL
J-7	1.49	1.31	390	375	26.39	25.06	39.8	33.1	BDL	BDL
J-8	1.37	1.28	386	362	49.51	46.19	36.2	32.8	BDL	BDL
J-9	1.15	1.01	425	417	44.37	43.52	55.4	51..3	0.009	0.005

BDL: Below Detectable Limit

Table-4: Details of Physicochemical Parameters

Sample Code	Total hardness (ppm)		Calcium hardness (ppm)		Magnesium hardness (ppm)		Calcium (ppm)		Magnesium (ppm)		Na (ppm)		K (ppm)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
J-1	400	360	150	140	250	220	60	56	61.00	53.68	94.12	92.06	3.06	2.57
J-2	430	390	210	220	220	170	84	88	53.68	41.48	75.24	73.71	5.12	4.28
J-3	310	290	190	210	120	80	76	84	29.28	19.52	29.31	27.71	1.29	1.37
J-4	460	440	290	280	170	160	116	112	41.48	39.04	9.37	8.29	0.88	0.71
J-5	800	710	540	520	260	190	216	208	63.44	46.36	55.21	53.06	3.55	3.67
J-6	780	740	390	360	390	380	156	144	95.16	92.72	19.02	18.48	11.07	11.44
J-7	640	580	410	400	230	180	164	160	56.12	43.92	12.41	11.5	0.89	0.61
J-8	750	700	470	450	280	250	188	180	68.32	61.00	18.09	17.24	0.62	0.57
J-9	830	780	440	410	390	370	176	164	95.16	90.28	17.05	11.27	0.55	0.54

Table-5: Details of Physicochemical Parameters

Sample Code	Total Alkalinity (ppm)		Carbonate Alkalinty (ppm)		Bicarbonate Alkalinity (ppm)		Hydroxyl Alkalinity (ppm)		Hydroxyl ion (ppm)		Carbonate ion (ppm)		Bicarbonate (ppm)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
J-1	390	370	BDL	BDL	390	370	BDL	BDL	BDL	BDL	BDL	BDL	475.8	451.4
J-2	320	310	BDL	BDL	320	310	BDL	BDL	BDL	BDL	BDL	BDL	390.4	378.2
J-3	290	300	BDL	BDL	290	300	BDL	BDL	BDL	BDL	BDL	BDL	353.8	366
J-4	410	420	BDL	BDL	410	420	BDL	BDL	BDL	BDL	BDL	BDL	500.2	512.4
J-5	390	370	BDL	BDL	390	370	BDL	BDL	BDL	BDL	BDL	BDL	475.8	451.4
J-6	560	520	BDL	BDL	560	520	BDL	BDL	BDL	BDL	BDL	BDL	683.2	634.4
J-7	480	430	BDL	BDL	480	430	BDL	BDL	BDL	BDL	BDL	BDL	585.6	524.6
J-8	390	370	BDL	BDL	390	370	BDL	BDL	BDL	BDL	BDL	BDL	475.8	451.4
J-9	510	540	BDL	BDL	510	540	BDL	BDL	BDL	BDL	BDL	BDL	622.2	658.8

BDL: Below Detectable Limit

Table-6: Details of Irrigation Parameters

Sample Code	%Na		SAR		RSC		KR		MH	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
J-1	33.96	35.86	2.06	2.13	0.08	BDL	0.52	0.56	61.93	60.53
J-2	27.50	29.05	1.59	1.63	2.09	1.52	0.39	0.42	50.56	42.99
J-3	17.11	17.21	0.73	0.71	0.34	BDL	0.21	0.21	38.13	27.10
J-4	4.27	3.96	0.19	0.17	0.92	0.32	0.04	0.04	36.39	35.80
J-5	13.07	13.97	0.85	0.87	8.08	6.71	0.15	0.16	31.97	26.29
J-6	4.99	5.10	0.30	0.30	4.21	4.22	0.05	0.05	49.39	50.74
J-7	4.07	4.16	0.21	0.21	3.09	2.91	0.04	0.04	35.38	30.52
J-8	5.02	5.12	0.29	0.28	7.07	6.48	0.05	0.05	36.77	35.16
J-9	4.32	3.08	0.26	0.18	6.21	4.62	0.05	0.03	46.38	46.83

BDL: Below Detectable Limit

Table-7: Correlation Matrix of waters

	pH	EC (µmhos/cm)	TDS (ppm)	Salinity (ppm)	TH (ppm)	TA (ppm)	HCO_3^- (ppm)	F^- (ppm)	Cl^- (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Na (ppm)	K (ppm)	SO_4^{2-} (ppm)	PO_4^{3-} (ppm)	NO_3^- (ppm)
pH	1.000															
EC (µmhos/cm)	-0.660	1.000														
TDS (ppm)	-0.660	1.000	1.000													
Salinity (ppm)	-0.661	1.000	1.000	1.000												
TH (ppm)	-0.726	0.901	0.901	0.901	1.000											
TA (ppm)	-0.349	0.701	0.701	0.701	0.724	1.000										
HCO_3^- (ppm)	-0.349	0.701	0.701	0.701	0.724	1.000	1.000									
F^- (ppm)	-0.014	-0.222	-0.222	-0.222	0.055	0.250	0.250	1.000								
Cl^- (ppm)	-0.499	0.897	0.897	0.897	0.914	0.806	0.806	-0.009	1.000							
Ca^{2+} (ppm)	-0.740	0.857	0.857	0.857	0.903	0.465	0.465	-0.210	0.831	1.000						
Mg^{2+} (ppm)	-0.458	0.655	0.655	0.655	0.795	0.842	0.842	0.411	0.720	0.457	1.000					
Na (ppm)	0.144	-0.647	-0.647	-0.647	-0.432	-0.504	-0.504	0.452	-0.705	-0.499	-0.191	1.000				
K(ppm)	-0.013	0.072	0.073	0.072	0.230	0.364	0.364	0.293	0.237	-0.001	0.479	0.127	1.000			
SO_4^{2-} (ppm)	0.086	-0.052	-0.052	-0.052	-0.162	-0.174	-0.174	-0.280	-0.302	-0.238	0.002	0.400	0.439	1.000		
PO_4^{3-} (ppm)	0.271	-0.667	-0.667	-0.667	-0.626	-0.252	-0.252	0.307	-0.731	-0.750	-0.237	0.572	-0.233	0.064	1.000	
NO_3^- (ppm)	-0.534	0.611	0.611	0.611	0.419	0.104	0.104	-0.431	0.262	0.391	0.315	-0.157	0.062	0.568	-0.326	1.000

Table-8 Cultural, Morphological and Biochemical characters of identified *bacterial*spp in ground water: Pre Monsoon

Sample code	MPN count/100ml	No. of *Bacterial* Colonies	*Bacterial* Colony Morphology on EMB agar	Grams stain	Motility	BIOCHEMICAL TESTS *(IMViC TESTS)							*Bacterial*spp identified
						I	MR	VP	C	CA	OX	UR	
J-1	10	Colony -1	Colour less	-ve	Motile	-	-	-	-	-	+	-	*Pseudomonas*
J-2	70	Colony -1	Green metallic sheen	-ve	Motile	+	+	-	-	+	-	-	*E.Coli*
		Colony- 2	Brown center pink	-ve	Motile	-	-	+	+	+	-	-	*Enterobacter*
J-3	16	Colony -1	Colour less	-ve	Motile	-	-	-	-	-	+	-	*Pseudomonas*
		Colony- 2	Light pink	-ve	Motile	-	+	-	-	+	-	+	*Proteus*

* I = Indole, MR= Methyl red, VP= VogesProskauer, C= Citarte, CA= Catalase, OX= Oxidase, UR= Urease

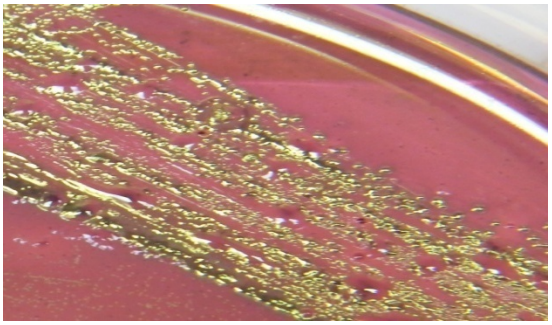
Table-9 Cultural, Morphological and Biochemical characters of identified *bacterial*spp in ground water: Post Monsoon

Sample code	MPN count/100ml	No. of *Bacterial* colonies	*Bacterial* Colony Morphology on EMB agar	Grams stain	Motility	BIOCHEMICAL TESTS *(IMViC TESTS)							*Bacterial*spp identified
						I	MR	VP	C	CA	OX	UR	
J-1	160	Colony -1	Green metallic sheen	-ve	Motile	+	+	-	-	+	-	-	*E.Coli*
J-2	180	Colony -1	Green metallic sheen	-ve	Motile	+	+	-	-	+	-	-	*E.Coli*
		Colony- 2	Colour less	-ve	Motile	-	-	-	-	-	+	-	*Pseudomonas*
J-3	35	Colony -1	Purple center pink	-ve	Non Motile	-	-	+	+	+	-	-	*Klebsiella*

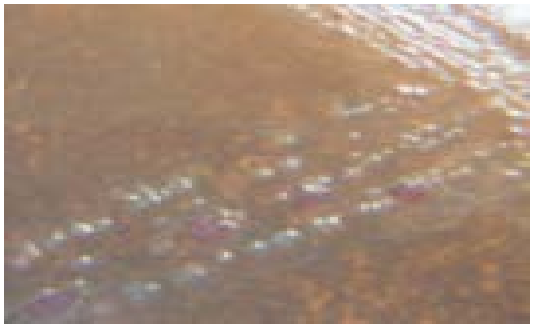
* I = Indole, MR= Methyl red, VP= VogesProskauer, C= Citarte, CA= Catalase, OX= Oxidase, UR= Urease

Figure-2: Photographs of *bacterial species* identified in waters of Jaggayyapeta Pre monsoon

J-1:pseudomonas

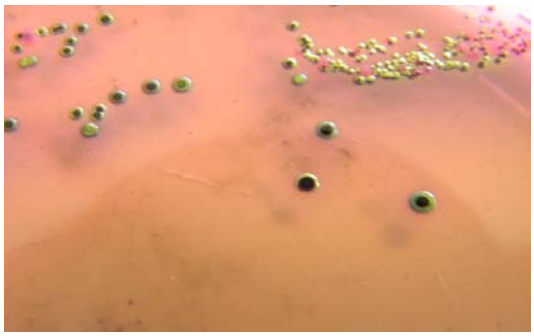


J-2: *E.Coli&Enterobacter*

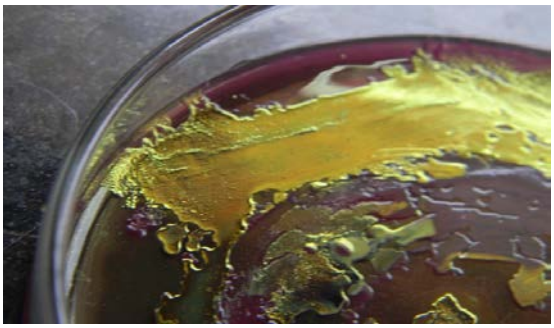


J-3: *Pseudomonas & Proteus*

Fig-3: Photographs of *bacterial species* identified in waters of Jaggayyapeta Post monsoon



J-1: *E.Coli*



J-2*: E.Coli& Pseudomonas*

J-3: *Klebsiella*

3.1. Physicochemical Parameters:

pH: pH levels during pre monsoon and post monsoon seasons range from 7.08-7.81 and 6.90-7.75 respectively. pH values of ground waters of both the seasons are within the permissible limits (IS of drinking water standards 6.5 – 8.5)

EC: EC levels range from 1005-2460 µmhos/cm and 900-2065 µmhos/cm in ground waters during pre and post monsoon seasons.

TDS: TDS of ground waters range from 714-1747 ppm during pre monsoon season while TDS ranges from 639-1466 ppm. The levels of TDS in waters during pre and post monsoon seasons exceeded the permissible limits (5800ppm) of drinking water standards.

TH: TH of ground waters during pre monsoon season ranges from 310-830 ppm. TH of ground waters range from 290-780 ppm during post monsoon season. The values crossed the permissible limit (300ppm) in case of waters during pre monsoon season. In case of post monsoon season except in sample J-3, the values crossed the permissible limit.

TA: TA of waters range from 290-560 ppm during pre monsoon season and during post monsoon season it varies from 300-540 ppm and all these levels exceeded the permissible limits (200ppm) of drinking water standards and all these values crossed the permissible limits. Higher values of TA change the taste of waters.

CO_3^{2-} : Carbonate levels of waters during pre and post monsoon were observed at BDL.

HCO_3^-: Bicarbonate values of waters range from 353.8-683.2 ppm during pre monsoon season and it ranges from 366-658.8 ppm during post monsoon season.

Chloride: Chloride ion concentration in waters during pre monsoon season varies from 160-455 ppm. The values in case of water samples J-1and J-2 are within the permissible limit (200ppm) of drinking water standards while the values in case of other samples exceeded the permissible limit. It ranges from 142-428ppm during post monsoon period. The levels of Chloride in water samples J-1, J-2 and J-3 are within the permissible limits. In other samples the concentration of chloride crossed the permissible limit.

Sulphate: Sulphate ion concentration in waters during pre monsoon season varies from 36.2-125.6 ppm while it ranges from 32.8-120.3 ppm during post monsoon season and these values are within the permissible limit of drinking water standards.

Phosphate: In waters near Agricultural activity areas, Phosphate ion concentration ranges from 0.003-0.024 ppm and these values are within the permissible limit (5 ppm) while it ranges from 0.003-0.018 ppm during post monsoon season.

Nitrate: Nitrate ion concentration in waters during pre monsoon season varies from 20.35-55.12 ppm. In case of sample J-2, Nitrate ion concentration exceeded the permissible limit while in other samples nitrate ion concentration values are within the permissible limit (45 ppm). In case of water samples it varies from 17.1-51.2 ppm during post monsoon season. In case of sample J-2, nitrate ion concentration exceeded the permissible limit while in other samples it is below the permissible limit.

Ca^{2+}: Calcium ion concentration in waters during pre and post monsoon seasons varies from 60-216 ppm and 56-208 ppm respectively. During pre monsoon season, Ca+2 ion concentration in sample J-1 is within the permissible limit while in other samples it crossed permissible limit. In case of Post monsoon season, Ca+2 ion concentration in sample J-1 is within the permissible limit while in other remaining samples it exceeded the permissible limit. .

Mg^{2+}: Magnesium ion concentration in waters during pre monsoon season varies from 29.28-95.6 ppm. In sample J-3, it is within the permissible limit while in other samples it is above the permissible limit. Its concentration in post monsoon samples ranges from 19.52-92.72 ppm. Its concentration in sample J-3, it is within the permissible limit and in the remaining samples it crossed the permissible limit (30 ppm) of drinking water standards.

Na^+: Na ion concentration in waters during pre and post monsoon season ranges from 9.37-94.12ppm and 8.29-92.06 ppm and the values are within the permissible limit of WHO standards.

K^+: In waters during pre and post monsoon season K ion concentration are 0.55-13.07 ppm and 0.54-12.44 ppm respectively.

Dissolved Oxygen (DO): The dissolved oxygen should be 4ppm for the waters and suitable for aquatic animals. In case of Pre monsoon season, DO value is within 4 ppm. In case of post monsoon water samples DO value is above 4 ppm in sample J-2 and in the remaining samples DO is below 4 ppm.

3.2. Correlation Analysis:

- EC is strongly is strongly correlated with TDS, Salinity, TH and Ca^{2+} and moderately correlated with TA, HCo^{3-} , Mg^{2+} and No^3-
- TDS is strongly correlated with Salinity, TDS, TH, Cl^- , Ca^{2+} and moderately correlated with TA, HCO_3^- , Mg^{+2} and NO_3^-

- Salinity is strongly correlated with TH, Cl^- , Ca^{2+} and moderately correlated with TA, HCO^{3-} , Mg^{2+} and NO_3^-
- TH is strongly correlated with Cl^- , Ca^{2+} and Mg^{2+} while it is moderately correlated with TA and HCO_3^-
- TA is strongly correlated with HCo^{3-} , Cl^- , and Mg^{+2}
- HCO_3^- is strongly correlated with Cl^- and Mg^{2+}
- Chloride is strongly correlated with Ca^{2+} and Mg^{2+}

3.3. Irrigation parameters:

% Na: Percent Sodium in water samples during pre and post monsoon seasons are 4.07-33.96me/L and 3.08-35.86me/L respectively. All the values are within the permissible limit (60me/L) of irrigation standards**.**

SAR: SAR in water samples during pre and post monsoon seasons range from 0.19-2.06 and 0.17-2.13 me/L respectively. All the values are within the permissible limit of irrigation standards. (26me/L)

RSC: RSC value in waters during pre monsoon season ranges from 0.08-8.08. The values in case of sample J-2,J-5, J-6,J-7,J-8 and J-9 exceeded the permissible limt while in other remaining samples RSC value is within the permissible limit. During post monsoon season it varies from 0.32-6.71 me/L. In case of samples J-1 and J-3 it is at BDL. In case of samples J-2 and J-4, it is within the permissible limit while in other samples it crossed the permissible limit.

Kelly's Ratio: KR in water samples during pre monsoon season ranges from 0.04-0.52 and during post monsoon season it ranges from 0.03-0.56. All the values are above the permissible limit (1).

Magnesium Hazard: MH values in majority of water samples are within the permissible limit (50) of irrigation standards indicating the absence of MH in waters.

3.4. Microbial Analysis:

During pre monsoon season the In sample J-1 the MPN count was observed as 10 per 100ml and the bacterial species is *Pseudomonas*. In sample J-2 the MPN count was observed as 70 per 100ml bacterial species identified are *E,Coli* and *Enterobacter*. In sample J-3 the MPN count was 16 per 100ml and the bacterial species identified are *Pseudomonas* and *Proteus*. During post monsoon season the In sample J-1 the MPN count was observed as 160 per 100ml and the bacterial species is *E.Coli*. In sample J-2 the MPN count was observed as 180 per 100ml bacterial species identified are *E,Coli* and *Pseudomonas*. In sample J-3 the MPN count was 35 per 100ml and the bacterial species identified is *Klebsiella.*

4. Conclusions:

The pH of waters during pre and post monsoon seasons are within the permissible limits of drinking water standards. Higher TDS of waters during both pre and post monsoon season indicated the presence of soluble solid matter in waters which can change the characters of waters. Higher EC values of waters during pre and post monsoon indicated the saline nature of waters. The salinity levels of waters during pre and post monsoon also revealed the saline nature of waters. DO values of waters during pre and post monsoon are within 4 ppm indicating the waters unsuitability for aqua culture purposes. Fluoride levels in some water samples during pre and post monsoon crossed the permissible limit of drinking water standards indicating the Fluoride contamination of waters . Chloride ion concentration in majority samples of pre and post monsoon crossed the permissible limit indicating the corrosive nature of waters. Nitrite concentrations in all samples except in one sample (J-2) are within the permissible limit. Sulphate ion concentration in both pre and post monsoon water samples are within the permissible limit indicating the non discharge of effluent waters into ground water sources. Phosphate ion concentrations are observed at BDL and with very low concentrations. Total hardeness of waters during pre and post monsoon seasons crossed the permissible limit indicating the encrustative nature of waters and making the waters unsuitable for drinking purposes. Higher values of Calcium in majority water samples of pre and post monsoon season indicate the encrustative nature of waters and making the waters unsuitable for domestic purposes. Higher values of Mg in all samples of pre and post monsoon season crossed the permissible limit indicating the Magnesium Hazard of waters. The concentration of Na and K in all waters of both pre and post monsoon are within the permissible limit of WHO standards. Total Alkalinity of waters during pre and post monsoon season crossed the permissible limit of drinking water standards and the higher values of TA can change the taste of waters unsuitable for drinking purposes.

The research results revealed that the waters are chemically contaminated due to the higher values of TDS, Salinity, Chloride, TH, Ca, Mg and TA and making the waters unsuitable for drinking purposes. Lower values of DO (<4ppm) are unsuitable for aquaculture purposes. Lower values during pre and post monsoon season of irrigation parameters like %Na, SAR and KR indicated the suitability of waters for irrigation purposes. Higher values of RSC in majority water samples during pre and post monsoon season revealed the unsuitability of

waters for irrigation purposes.MH values in majority water sample during pre and post monsoon season are within the permissible limit (50) of irrigation standards indicating the absence of Magnesium Hazard as such the quality of soil maynot be depleted and the crop yields will not be reduced and the waters are suitable for irrigation purposes.

The presence of MPN count in water sample indicated the microbial contamination of waters. The presence of pathogenic bacterial species like *Pseudomonas*, *E.Coli*, *Enterobacter*, indicated the bacterial contamination of waters and making the waters unsuitable for drinking purposes. The presence of these pathogenic bacterial species can cause water borne diseases like Typhoid, Cholera, Jaundice and gastro intestinal problems and deplete the health of the humans if consumed for drinking purposes.

The waters are to be treated properly by the available treatment methods like Nano filteration and ultra filtration to minimize the TDS to make waters suitable for drinking purposes. The waters are further treated with disinfection and sterilization to remove the bacterial contamination for safeguarding the health of the public in the study area and making the waters suitable for proper utilization.

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