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Quality Evaluation of Ground Water near Sugar Industrial Area

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ABSTRACT

Sugar industries rank second among the agro based industries in India. Sugar industry is seasonal in nature and operates only for 120 to 200 days in a year. A significant large amount of waste is generated during the manufacture of sugar. Environmental pollution due to enhancement of industrial activities is one of the most significant problems of the century. Physiochemical parameters of water are enhanced due to discharge of untreated or partially treated industrial waste and sewage waste into water bodies. In the present research work it is proposed to collect ground water samples near to a sugar industry and the characterize then for physicochemical parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA), Na^+, K^+, Ca^{2+}, Mg^{2+}, Chloride, Sulphate, Nitrate and Phosphate around the Sugar industry to assess the impact of effluent on ground water. The irrigation parameters like Percent Sodium (%Na), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Kelly's Ratio (KR) and Magnesium hazard (MH) are determined to assess the suitability of water for irrigation purposes. Metal ions viz., Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Ag, Cd, Cs, Ba and Pb are characterized to assess the metal toxicity in water. The water is further analyzed for microbial species to evaluate the degree of bacterial contamination of water. The research results revealed that water is chemically contaminated due to higher TDS and TH and Ca^{2+}, and chloride ion concentration. Lower concentration of metal ions in water indicates the absence of metal toxicity. Higher levels of Magnesium hazardous that the water is with higher magnesium hazardous which can deplete the quality of soil and the yield of the crap will be reduced in the study area. Presence of bacterial species Viz., Enterobacter, Proteus, Klebsiella, and E.coli in water can cause water borne disease if consumed for drinking purposes. Hence, this water is to be properly treated to remove the chemical contamination. Disinfection and sterilization methods are to be adopted for controlling the microbial contamination in water to protect the health of the public in the study area.

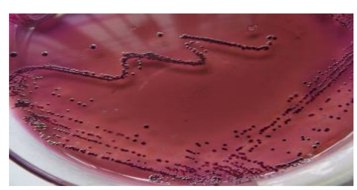
Graphical Abstract

S-1

***(Enterobacter,** Proteus)*

S-2

(Enterobacter, Klebsiella)



S-3

(E.Coli, Enterobacter)

The Photographs of the bacterial species identified in Ground water and Sugar effluent are presented in figures from S-1 to S-3

Keywords: Ground water, Effluent, Characterization, Metalion, Bacteria.

INTRODUCTION

Environmental pollution due to enhancement of industrial activities is one of the most significant problems of the century. Pollution in soil and water is strictly related to human activities such as industry, agriculture, burning of fossil fuels, mining and metallurgical processes and their waste disposal [1]. All types of effluents and most of by products from any type of industry create a most serious pollution to the water bodies and soil bodies [2]. The contamination of soil is often a direct or indirect consequence of industrial activities [3]. The ever-increasing demand on irrigation water supply, farmlands is frequently faced with utilization of poor quality irrigation water. Due to shortage of canal irrigation water formers use industrial effluents which being discharged in canal [4]. Since, the use of such effluents as irrigation water may introduce some metal ions, which may accumulate in the plants [5]. Soil properties are adversely affected by high concentration of metal ions, rendering contaminated soils unsuitable for crop production [6, 7]. Metals can also be transported from soil into groundwater resulting in to soil contamination and inhibiting growth of plants [8]. The heavy metals accumulate in the plant material grown in these soils, which will ultimately go to human body through food chain directly or indirectly causing a number of physicomental problems.

Sugar industry is seasonal in nature and operates only for 120 to 200 days in a year. A significant large amount of waste is generated during the manufacture of sugar and contains a high amount of production load particularly in items of suspended solids, organic matters, effluent, sludge, presumed and bagasses [9]. This waste water is disposed into nearby water bodies and they are being used for irrigation. The discharge of this effluent into water bodies or on soil is causing a serious problem of water pollution resulting in severe damage to the flora and fauna and environmental degradation [10]. Fish mortality and damage to paddy crops due to sugar industry waste-water entering agricultural land have been reported [11]. Keeping in view the discharge of sugar industrial effluent in to nearby water sources it is proposed to characterize the effluent of the sugar industry and the nearby ground water samples to evaluate the quality or ground water to suggest require remedial measures.

MATERIALS AND METHODS

The study area includes 12 locations around Sugar industrial unit in East Godavari reason towards East, west, North and South at a distanced of 0-1, 2-3 and 3-5Km respectively 12-represanted ground water samples were collected and the details of Sample code, location, source type and coordinates are presented in table 1 and the study area Map is presented in figure 1

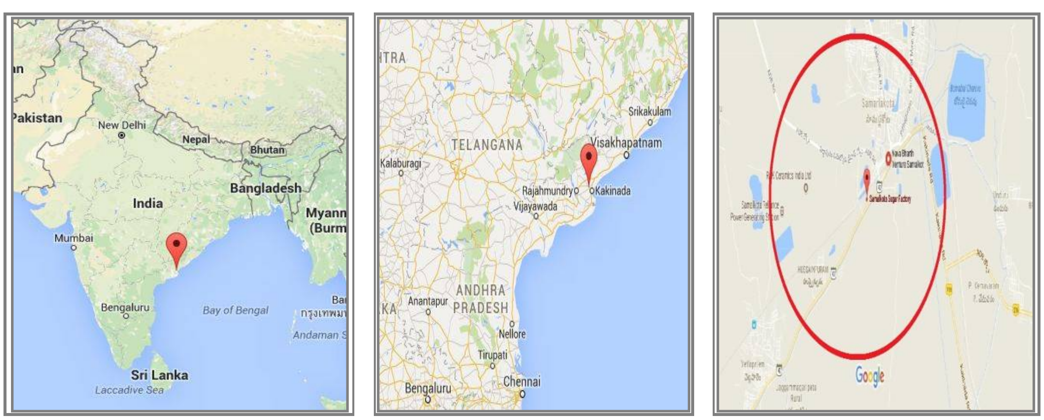


Figure 1. Satellite picture of study area Map of Sugar Industry

Table 1. Sampling Locations and distance from the source (Sugar industry)

S.No	Location	Source	Distance and Direction	GPS-Coordinates	
				Latitude	Longitude
S-1	Modeswara temple,	OW	E(0-1km)	N-17^0 02' 517''	E-82^0 10' 025''
S-2	Bhimewara swami temple	BW	E (2-3km)	N-17^0 02' 558''	E-82^0 10' 270''
S-3	Ayyappa temple	OW	E (3-5km)	N-17^0 02'934''	E-82^0 10'737''
S-4	ICDS office near,	OW	W (0-1km)	N-17^0 02' 682''	E-82^0 09' 901''
S-5	L.N.Trades tiles shop,	OW	W (2-3km)	N-17^0 02' 958''	E-82^0 09' 201''
S-6	FCI Godowns,	BW	W (3-5km)	N-17^0 02' 658''	E-82^0 10' 154''
S-7	Near bridge	BW	N (0-1km)	N-17^0 02' 682''	E-82^0 09' 975''
S-8	Nukalamma temple,	OW	N (2-3km)	N-17^0 02' 812''	E-82^0 10' 209''
S-9	Vinayak temple,	OW	N (3-5km)	N-17^0 03' 052''	E-82^0 10' 469''
S-10	Sugar factory quarters,	OW	S (0-1km)	N-17^0 02' 321''	E-82^0 09' 606''
S-11	Hussanpuram	BW	S (2-3km)	N-17^0 01' 917''	E-82^0 09' 086''
S-12	Sugar Industry back,	OW	S (3-5km)	N-17^0 01' 839''	E-82^0 08' 933''

OW=Open well BW= Bore well. E-East-West, N-North, S-South.

Polythene containers were employed for sampling and preserved for analysis by following the standard procedures [12]. The samples were analyzed for physicochemical parameters which include pH, Electrical conductivity (EC) , Total Dissolved solids (TDS), Total Alkalinity (TA), Total hardness (TH), Ca^{2+} and Mg^{2+}, Na^+, K^+, Chloride, Sulphate and Phosphate. pH determined by pH meter (Global-DPH 505, India-Model) and Conductivity measured by the digital Conductivity meter (Global-DCM-900-Model). TDS is determined from the relation TDS = Electrical conductivity (EC) ×0.64. Chloride, TH, TA and Chloride are estimated by titrimetry. Fluoride, Sulphate, Nitrate and Phosphate have measured by Spectrophotometer (Model-167, Systronics), Na^+ and K^+ by Flame Photometer (Model-125, Systronics). The irrigation parameters determined for the water include Percent Sodium (%Na), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Kelly's Ratio (KR), Magnesium Hazard (MH) and the parameters are determined by the following relation

$$\text{Percent Sodium (\%Na)} = \frac{Na^+ X100}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \text{ (meq L}^{-1}\text{)}$$

$$\text{Sodium Adsorption Ratio (SAR)} = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \text{ (meq L}^{-1}\text{)}$$

$$\text{Residual Sodium Carbonate (RSC)} = (CO_3^{2-}\ HCO_3^-) - (Ca^{2+} + Mg^{2+}) \text{ (meq L}^{-1}\text{)}$$

$$\text{Kelly's Ratio (KR)} = \frac{Na^+}{Ca^{2+} + Mg^{2+}}$$

$$\text{Magnesium Hazard (MH)} = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} X100$$

Metal ions: The representative Ground water samples were analyzed for metal ions viz., Be, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Ag, Cd, Ba and Pb by Inductive Coupled Plasma Mass Spectrometry (ICP-MS) technique (Model-7700 Make-Agilent Technologies). Samples are diluted with milli equivalent water, maintain conductance less than 1000 µs cm^{-1} and acidified with 100µL of supra pure HNO_3. Rh used as Internal Standard (ISTD) and the samples were processed as per the manual instructions of the instrument and introduced in to the instrument for analysis.

Table 2. Physicochemical characteristics of Sugar Industrial effluent and ground water

S. No	pH	EC (μmhos cm^{-1})	TDS ($mg L^{-1}$)	TA ($mg L^{-1}$)	TH ($mg L^{-1}$)	Ca^{H} ($mg L^{-1}$)	Mg^{H} ($mg L^{-1}$)	Ca^{2+} ($mg L^{-1}$)	Mg^{2+} ($mg L^{-1}$)
Effluent	5.0	14700	9408	1100	2300	1100	1200	440	292.8
S-1	7.4	639	408.96	110	740	100	640	40	156.16
S-2	7.2	2340	1497.6	250	280	190	90	76	21.96
S-3	7.2	677	433.28	140	430	80	350	32	85.4
S-4	7.1	1370	876.8	200	540	190	350	76	85.4
S-5	6.8	523	334.72	70	340	140	200	56	48.8
S-6	7.2	687	439.68	90	450	160	290	64	70.76
S-7	7.4	1620	1036.8	140	510	170	340	68	82.96
S-8	7.2	2610	1670.4	280	660	200	460	80	112.24
S-9	7.2	555	355.2	70	400	120	280	48	68.32
S10	7.1	945	604.8	110	510	130	380	52	92.72
S-11	7.2	1740	1113.6	150	600	250	350	100	85.4
S-12	7.0	2150	1376	110	970	280	690	112	168.36

Table 3. Physicochemical characteristics of Sugar industrial effluent and ground water

S. No	Na+ ($mg L^{-1}$)	K+ ($mg L^{-1}$)	Chloride ($mg L^{-1}$)	Nitrate ($mg L^{-1}$)	Sulphate ($mg L^{-1}$)	Phosphate ($mg L^{-1}$)	HCo_3^- ($mg L^{-1}$)	Co_3^{2-} ($mg L^{-1}$)	OH^- ($mg L^{-1}$)
Effluent	115	99	659.37	49.57	139	86	1100	BDL	BDL
S-1	29.88	33.1	673.55	5.53	43	1.4	100	BDL	BDL
S-2	211.4	92	4289.45	55.53	72	1.5	220	BDL	BDL
S-3	46.64	1.49	460.85	2.64	28	1.2	120	BDL	BDL
S-4	92.46	49.74	1985.2	10.43	163	21.6	170	BDL	BDL
S-5	26.25	0.7	709	14.29	19	1.4	70	BDL	BDL
S-6	43.33	0.47	709	17.31	24	1.6	80	BDL	BDL
S-7	175	2.7	2587.85	10.88	126	1.2	120	BDL	BDL
S-8	260.5	85.7	354.5	8.39	93	2.1	240	BDL	BDL
S-9	32.79	1.86	4324.9	9.13	207	2.1	60	BDL	BDL
S10	80.28	2.1	1098.95	23.25	132	0.8	100	BDL	BDL
S-11	118.71	38.26	2375.15	4.68	35	1.5	140	BDL	BDL
S-12	79.31	2.01	3934.95	7.50	24	2.3	100	BDL	BDL

Table 4. Metal ion concentration of Sugar Industrial effluent and ground Water

Sample Code	Li (ppm)	Be (ppm)	Al (ppm)	V (ppm)	Cr (ppm)	Mn (ppm)	Fe (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)
S-Ef	0.0127	0.0082	0.2620	0.0091	0.0507	0.0171	0.2541	0.0005	0.0336	0.1343
S-1	0.0003	BDL	0.0040	0.0079	0.0004	0.0002	0.0028	BDL	0.0011	BDL
S-2	0.0015	BDL	BDL	0.0006	0.0001	0.0003	BDL	BDL	0.0003	BDL
S-3	0.0003	BDL	0.0023	0.0026	0.0001	0.0284	0.0017	0.0001	0.0005	BDL
S-4	0.0008	BDL	0.0274	0.0084	0.0004	0.0031	0.0231	0.0001	0.0067	0.0068
S-5	0.0010	BDL	0.0057	0.0007	0.0001	0.0033	0.0169	BDL	0.0009	0.0002
S-6	0.0013	BDL	0.0051	0.0238	0.0000	0.0245	0.0100	BDL	0.0003	BDL
S-7	0.0002	BDL	0.0034	0.0006	0.0001	0.0009	0.0021	BDL	0.0006	0.0003
S-8	0.0015	BDL	0.0003	0.0036	0.0003	0.0083	0.0129	0.0004	0.0011	BDL
S-9	0.0007	BDL	0.0045	0.0064	0.0002	0.0007	0.0027	0.0001	0.0005	BDL
S-10	BDL	0.0002	BDL	BDL	0.0010	0.0003	0.0007	0.0025	BDL	0.0003
S-11	0.0002	BDL	50.51	0.0070	0.0002	0.0002	0.0021	BDL	0.0001	BDL
S-12	0.0003	BDL	0.0037	0.0038	0.0003	0.0082	BDL	0.0001	0.0014	0.0018

Microbial Analysis: The ground water samples collected in sterilized containers [**13**] are immediately processed for analysis for determining the MPN count by the Most Probable Number (MPN) technique for the enumeration for the *Coliform* count in water samples [**14, 15**] which involved the presumptive test using lactose broth and Nutrient Agar, confirmatory test using Eosin Methylene Blue (EMB) agar. Pure colonies isolated were subjected to grams stain, motility, Indole, Methyl red, Voges-Proskauer tests, Citrate utilization test, Urease test, Catalase and Oxidase test [**16**].

The analytical data related to physicochemical parameters are presented in tables 2 and 3. The data related to the metal ions in presented in table 4 and 5. The details of Irrigation parameters determined are presented in table 6 and the details of identified bacterial species are presented in table 7.

Table 5. Metal ion concentration of Sugar Industrial effluent and ground Water

Sample Code	Zn (ppm)	As (ppm)	Se (ppm)	Rb (ppm)	Sr (ppm)	Ag (ppm)	Cd (ppm)	Cs (ppm)	Ba (ppm)	Pb (ppm)
S-Ef	0.0493	0.0009	0.0004	0.0123	0.0006	BDL	0.0017	0.0004	0.0212	0.0166
S-1	0.0032	0.0006	0.0003	0.0092	0.3957	BDL	BDL	BDL	0.0756	BDL
S-2	0.0011	0.0001	0.0002	0.0036	0.2457	BDL	BDL	BDL	0.0423	BDL
S-3	0.0044	0.0001	0.0010	0.0017	0.5893	BDL	BDL	BDL	0.1512	BDL
S-4	0.0523	0.0016	0.0011	0.0286	0.4582	BDL	BDL	BDL	0.1021	0.0005
S-5	0.0049	BDL	0.0005	0.0012	0.3068	BDL	BDL	BDL	0.0809	BDL
S-6	0.0552	0.0006	0.0001	0.0002	0.1753	BDL	BDL	BDL	0.0137	BDL
S-7	0.0065	BDL	0.0004	0.0005	0.3087	BDL	BDL	BDL	0.0246	BDL
S-8	0.0010	0.0029	0.0016	0.0632	0.9100	BDL	BDL	BDL	0.2567	BDL
S-9	0.0012	0.0004	0.0006	0.0134	1.2466	BDL	BDL	BDL	0.2571	BDL
S-10	0.0014	0.0113	0.0001	0.0007	0.0040	0.4292	BDL	BDL	0.0001	0.0493
S-11	0.0051	0.0006	0.0001	0.0079	0.3749	BDL	BDL	BDL	0.0721	BDL
S-12	0.0052	0.0001	0.0005	0.0005	1.9341	BDL	BDL	BDL	0.2056	0.0001

*S-Ef: Sugar Effluent. S: Ground water samples near Sugar industry

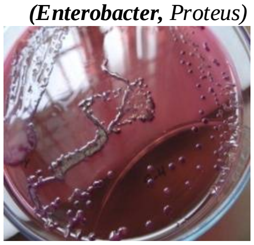
Table 6. Irrigation Parameters water samples near Sugar Industry

S.No	%Na (meq L^{-1})	SAR (meq L^{-1})	RSC (meq L^{-1})	Kelly's Ratio (KR)	MH
Effluent	9.44	1.04916	BDL	0.110	51.56
S-1	7.80	0.4826	BDL	0.089	86.2
S-2	53.74	5.51417	BDL	1.654	31.61
S-3	19.31	0.9876	BDL	0.240	81.02
S-4	25.24	1.74355	BDL	0.378	64.25
S-5	14.51	0.62338	BDL	0.170	58.23
S-6	17.51	0.89503	BDL	0.212	63.88
S-7	42.95	3.39647	BDL	0.758	66.12
S-8	42.74	4.44602	BDL	0.872	69.18
S-9	15.26	0.71889	BDL	0.181	69.48
S10	25.73	1.5596	BDL	0.348	74.04
S-11	28.71	2.122	BDL	0.436	57.74
S-12	15.27	1.11674	BDL	0.180	70.63

S-1
***(Enterobacter,** Proteus)*

S-2
(Enterobacter, Klebsiella)

S-3
(E.Coli, Enterobacter)

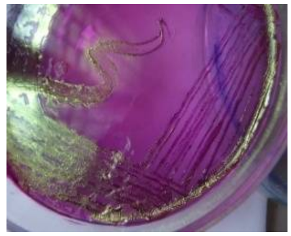


S-4
***(E.Coli, Enterobacter,** Proteus)*

S-5
***(E.Coli, Enterobacter,** Proteus)*

S-6
(E.Coli, Enterobacter)

S-7
(Enterobacter, Klebsiella)



S-8
(E.Coli)

S-9
(Enterobacter, Klebsiella)

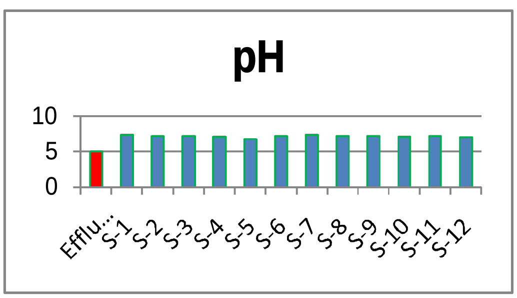
S-10
(Enterobacter, Klebsiella)

S-11
(Enterobacter Pseudomonas)

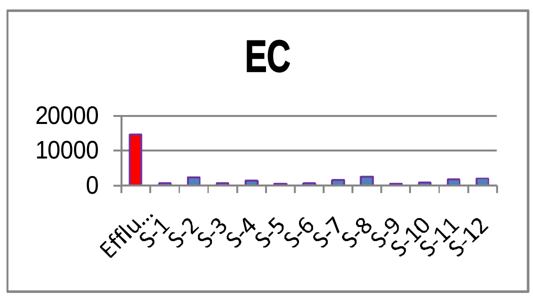
S-12
(Enterobacter, Klebsiella)

Sugar- EF
(Proteus)

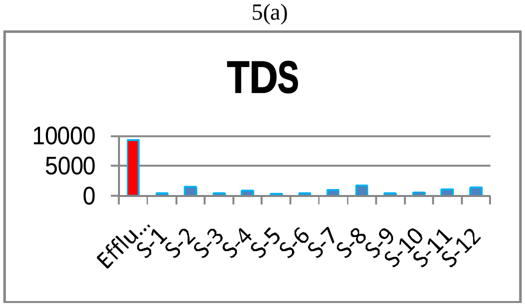
The Photographs of the bacterial species identified in Ground water and Sugar effluent and presented in figures from S-1 to S-12 and SEF respectively,

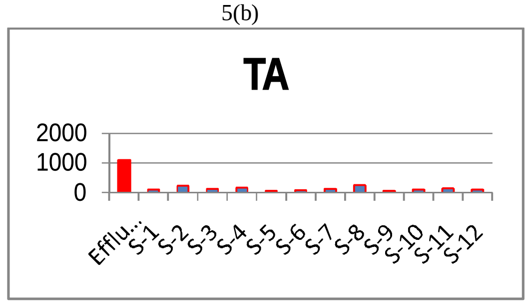


5(a)



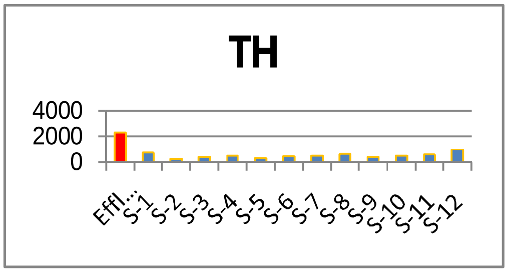
5(b)





5(c)

5(d)



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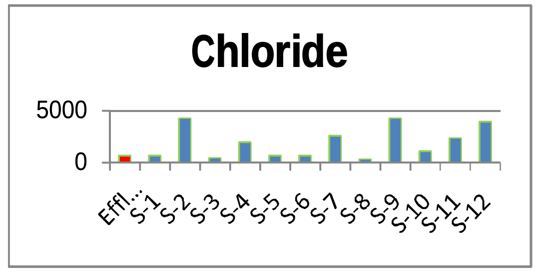

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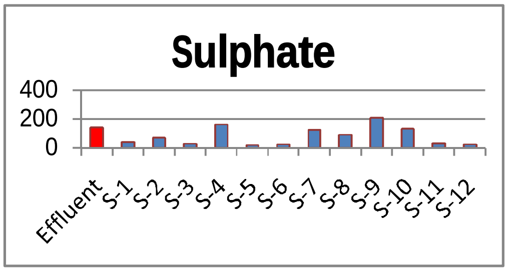

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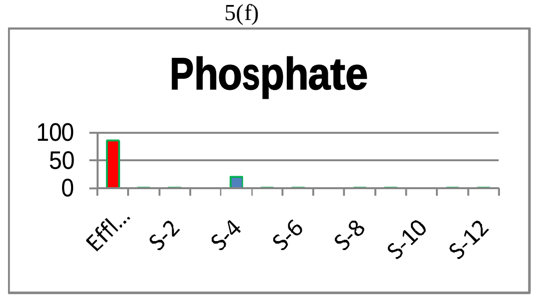

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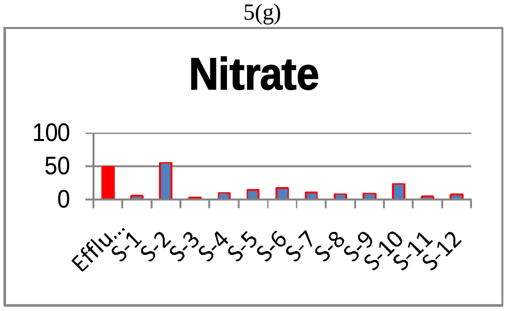
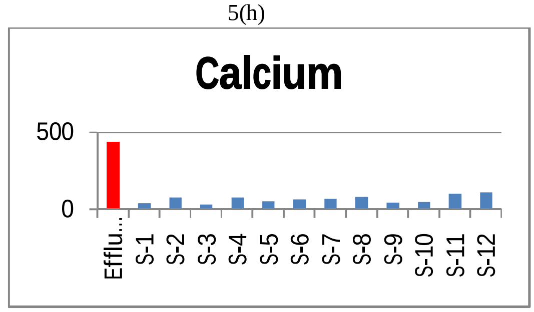
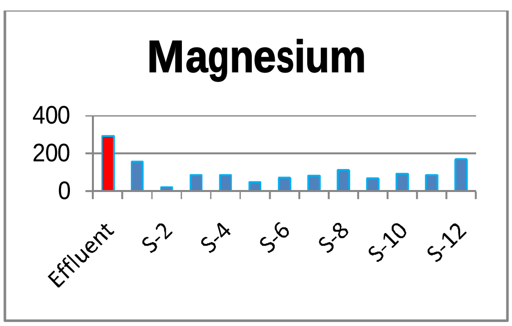


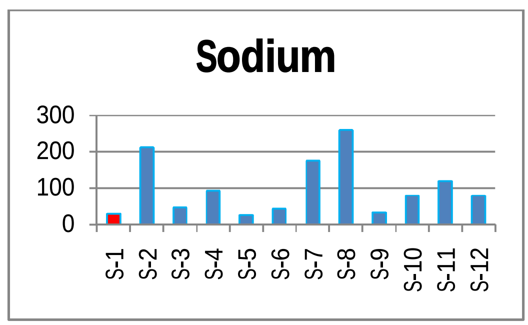
5(i)



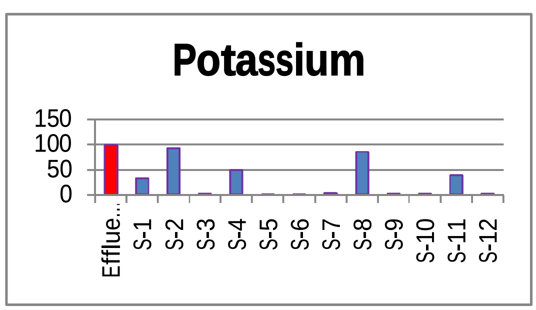
5(j)



5(k)

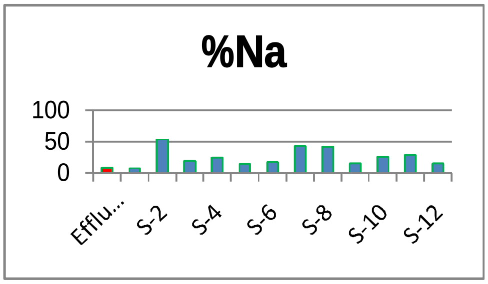


5(l)

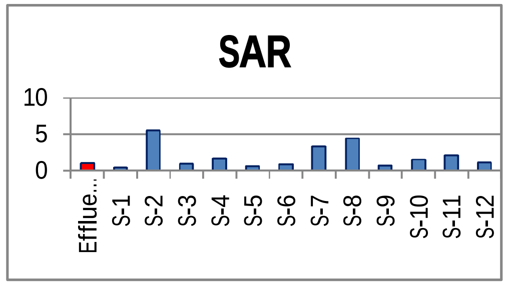


5(m)

The graphical representation of physicochemical parameters of ground water near Sugar industrial are shown in figures from 5(a)-5(m)



5.1(a)



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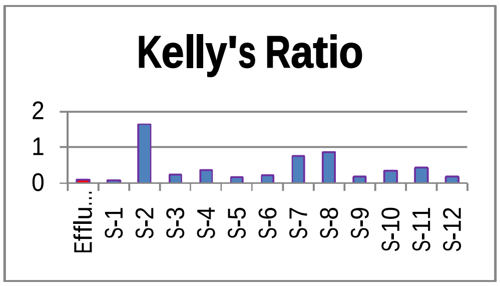
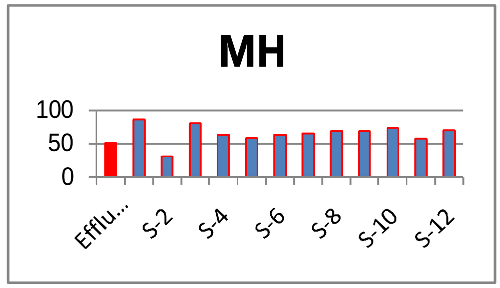


5.1(c)



5.1(d)

The Graphical representation of Irrigation Parameters of Water samples collected Near Sugar Industry are shown in figures 5.1(a)-5.1(d).

RESULTS AND DISCUSSION

pH: pH of effluent is 5.0 which indicates the acidic nature while pH of ground water ranges from 6.8-7.4 and it is in the range of drinking water standards (6.5-8.5).

EC: EC of effluent is 14700 µmhos cm^{-1} while EC of ground water ranges from 523-2340 µmhos cm^{-1}. EC of Samples S-2, S-4, S-7, S-8, S-11 and S-12 are found to be higher compared to others. Higher EC indicate the saline nature of water in the study area and the effluent has its impact on ground water in enhancing the EC value.

TDS: TDS of effluent is 9408 mg L^{-1} while its ranges from 334.72-1670.4 mg L^{-1}.TDS is higher in S-2, S-4, S-7, S-8, S-11 and S-12 indicating the presence of soluble solid matter in ground water. Higher TDS indicate the impact of effluent on ground water.

TA: Total alkalinity of effluent is 1100 mg L^{-1} while its ranges from70-280 mg L^{-1}. TA is higher in S-2 and S-8 indicating the change of taste of water in the study area location effluent impact only in locations S-2 and S-8 in present and in the remaining locations it is absent.

TH: TH of effluent is 230 mg L^{-1} while its ranges from 280-970 mg L^{-1} in ground water. All the values crossed the permissible limit of 300 mg L^{-1} except in water of sample-2. Higher values of Total Hardness indicate the encrustation nature of water in the study area effluent impact on ground water is present.

Ca^{H}: Calcium hardness of effluent is 1100 mg L^{-1} while it ranges from 100-280 mg L^{-1}.

Mg^{H}: Magnesium hardness of effluent is 1200 mg L^{-1} while it ranges from 90-690 mg L^{-1}.

Ca^{2+}: Calcium ion concentration in effluent is 440 mg L^{-1} while it ranges from 32-112 mg L^{-1}. Calcium ion concentration exceeds the permissible limit (75 mg L^{-1}) of drinking water standard in samples S-2, S-4, S-8, S-11 and S-12 indicating the encrustation nature of water. Impact of effluent is present on water samples S-2, S-4, S-8, S-11 and S-12 of the industry area location.

Table 7. Bacterial species identified in Ground water and Sugar industrial effluent

Sample code	MPN Count $100mL^{-1}$	No. of Bacterial Colonies	Bacterial colony morphology on EMB	Gram Stain	Motility	Biochemical Tests							*Bacteria identified*
						Indole	MR	VP	Citrate	CA	OX	UR	
S1	>1800	2	Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
			Light Pink	-ve	Motile	-ve	+ve	-ve	-ve	+ve	-ve	+ve	*Proteus*
S2	23	2	Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
			Pink Mucoid	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
S3	8	2	Metallic Sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.Coli*
			Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
S4	220	3	Metallic Sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.Coli*
			Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
			Light Pink	-ve	Motile	-ve	+ve	-ve	-ve	+ve	-ve	+ve	*Proteus*
S5	1600	3	Metallic Sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.Coli*
			Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
			Light Pink	-ve	Motile	-ve	+ve	-ve	-ve	+ve	`-ve	+ve	*Proteus*
S6	<1800	2	Metallic Sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.Coli*
			Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
S7	1600	2	Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
			Pink Mucoid	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
S8	920	1	Metallic Sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.Coli*
S9	920	2	Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
			Pink Mucoid	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
S10	>1800	2	Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
			Pink Mucoid	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
S11	<2	2	Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
			Color Less	-ve	Motile	-ve	-ve	-ve	-ve	-ve	+ve	-ve	*Pseudomonas*
S12	>1800	2	Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
			Pink Mucoid	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
SEF	11	1	Light Pink	-ve	Motile	-ve	+ve	-ve	-ve	+ve	-ve	+ve	*Proteus*

*SEF Sugar Industrial Effluent

TA: Total alkalinity of effluent is 1100 mg L^{-1} while its ranges from70-280 mg L^{-1}. TA is higher in S-2 and S-8 indicating the change of taste of water in the study area location effluent impact only in locations S-2 and S-8 in present and in the remaining locations it is absent.

TH: TH of effluent is 230 mg L^{-1} while its ranges from 280-970 mg L^{-1} in ground water. All the values crossed the permissible limit of 300 mg L^{-1} except in water of sample-2. Higher values of Total Hardness indicate the encrustation nature of water in the study area effluent impact on ground water is present.

Ca^{H}: Calcium hardness of effluent is 1100 mg L^{-1} while it ranges from 100-280 mg L^{-1}.

Mg^{H}: Magnesium hardness of effluent is 1200 mg L^{-1} while it ranges from 90-690 mg L^{-1}.

Ca^{2+}: Calcium ion concentration in effluent is 440 mg L^{-1} while it ranges from 32-112 mg L^{-1}. Calcium ion concentration exceeds the permissible limit (75 mg L^{-1}) of drinking water standard in samples S-2, S-4, S-8, S-11 and S-12 indicating the encrustation nature of water. Impact of effluent is present on water samples S-2, S-4, S-8, S-11 and S-12 of the industry area location.

Mg^{2+}: Magnesium ion concentration in effluent is 292.8 mg L^{-1} while it ranges from 21.96-168.36 mg L^{-1}. Concentration of Mg^{2+} except in sample S-2 crossed the permissible limit of drinking water standards (30 mg L^{-1}). The results indicate the effluent influence in all the ground water samples except on S-2 sample of the study area location.

Phosphate: Phosphate levels in effluent are 86 mg L^{-1} while it ranges from 0.8-21.6 mg L^{-1}. Higher levels of Phosphate are observed in sample S-4 indicating the discharge of agriculture runoff in to ground water source in sampling location S-4.

Co_3^{2-}& OH^-: Carbonate and Hydroxyl levels are observed at below detectable limits (BDL) in all water samples and effluent.

HCo_3^-: Bicarbonate in effluent is 1100 while its ranges from 70-240 mg L^{-1}.

Na^+: Na^+ ion concentration in effluent is 115 mg L^{-1} while its ranges from 26.25-260.5 mg L^{-1}. Na^+ ion concentration crossed the permissible limit of 250 mg L^{-1} of WHO standard only in sample S-8 and in all other samples it is below the permissible limit.

K^+: K^+ ion concentration in effluent is 99 mg L^{-1} while its ranges from 0.7-92 mg L^{-1}. K^+ ion concentration exceeds the limits (12 mg L^{-1}) in Sample S-1, S-2, S-4, S-8, S-11. Influence of effluent is present on samples S-1, S-2, S-4, S-8 and S-11.

Chloride: Chloride ion concentration in effluent is 659.37 mg L^{-1} while its ranges from 354.5-4324.9 mg L^{-1}. Chloride levels are higher in all samples of ground water indicating the corrosive nature of water. Influence of effluent on ground water is present and in addition there are other factors which enhanced the chloride levels in S-2, S-4, S-5, S-6, S-7, S-8, S-9, S-11 and S-12 sampling locations.

Nitrate: Nitrate levels in effluent is 49.57 mg L^{-1} while its ranges from 2.645-55.53 mg L^{-1} nitrate levels crossed the permissible limit (45 mg L^{-1}) of drinking water only in sample S-2 and in other water samples it is within the permissible limit. Higher levels indicate the possibility of discharge of agriculture runoff in to the water source in S-2 sample location.

Sulphate: Sulphate levels in effluent are 139 mg L^{-1} while its ranges from 19-207 mg L^{-1}. All the values are within the permissible limit of drinking water standard (350 mg L^{-1}) indicating the non-discharge of effluent in to water sources.

Metal ions: The metal ion concentration of Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Ag, Cd, Cs, Ba and Pb are on the lower side of the permissible limit of drinking water standards indicating the water are free from Metal toxicity.

%Na: Percentage Sodium in effluent is 9.44 meq L^{-1} while it ranges from 7.80-53.74 and all values are within the permissible limit (60 meq L^{-1}) of irrigation standards indicating the suitability of ground water for irrigation purposes.

SAR: SAR of effluent is 1.04 meq L^{-1} while it ranges from 0.62-5.51 meq L^{-1}. All the values are within the permissible limit of irrigation standard (26 meq L^{-1}) indicating the suitability of water for irrigation.

RSC: RSC of effluent and ground water are observed at below detectable limit (4.5 meq L^{-1}) indicating the suitability of water for irrigation.

KR: KR of effluent is 0.11 and it ranges from 0.17-1.65.KR of sample S-2 exceed the permissible limit (1.0) of irrigation standards while in other samples it is within the permissible limit.

MH: MH of effluent is 51.56 while it ranges from 31.61-81.02.MH is within the permissible limit (50) of irrigation standard in sample S-2 while it crossed the permissible limit indicating the Magnesium Hazardous of water in all the remaining sampling locations. Higher values of MH indicate the Magnesium Hazardous water. Higher MH depletes the soil quality which in turn reduces the yield of the crops in the study area locations.

Bacterial species: The effluent and ground water samples were observed with MPN count greater than two indicates the Microbial contamination while in sample S-11, the MPN count less than 2. The sugar effluent was observed with bacterial species proteus, while the ground water samples locations from S-2 to S-12 were observed with a combination of bacterial species like *Klebsiella, E.Coli., Enterobacter, E.Coli., Proteus, E.Coli., Klebsiella, Enterobacter., Enterobacter, Pseudomonas*. It was observed in the effluent will have effect on ground water sample S-5 while in the other ground water samples bacterial species other than *proteus* were observed indicating the bacterial contamination from other surrounding sources near the industrial area under study.

APPLICATIONS

The results of the chemical analysis indicate chemical contamination of ground waters near industrial areas confirming the waters unsuitability of these waters for drinking or domestic purposes. The lower metal ion concentrations recorded in this research work are useful in confirming the non toxicity of ground waters. The irrigation parametric values are useful in determining the suitability of waters for irrigation purposes. The results of microbial analysis clearly indicate the bacterial contamination of waters with pathogenic bacterial species like *E. Coli, Proteus, Enterobacter, Klebsiella and Pseudomonas which can cause waterborne diseases and can cause concern on human health.*

CONCLUSIONS

pH of water indicated slight alkaline nature. Higher EC values in fifty percent of water samples indicate saline nature of water. Higher TDS in fifty percent of water samples also confirms the presence of soluble solid matter in water. Higher TH alkalinity in only two sampling locations can change the taste of water. Higher TH and Ca^{2+} ion concentration of water in all sampling locations indicate the encrustative nature of water and hence, the water unsuitable for drinking and domestic purpose. Higher magnesium concentration can cause laxative nature to water and can enhance magnesium hazard of water. Absence of carbonate indicates the absence of carbon contact in water. Presence of bicarbonate indicates the freshness of water. Sodium ion concentration is within the permissible limit while Potassium ion concentration crossed the permissible limit. The chloride ion concentration is higher indicating the corrosion nature of water. Higher concentration of nitrate in sample 2 location and higher concentration of phosphate in S-4 location indicates the discharge of agriculture runoff in to the water sources in the study area locations. Sulphates values are within the limits indicate the non-discharge of effluent in to the water sources. The research results indicated that the water is chemically contaminated and proper treatment by the available treatment methods for considering then for drinking or domestic uses. Lower concentrations of metal ions revealed the absence of metal toxicity in water. The irrigation parametric values %Na, SAR and RSC are within the permissible limit of irrigation standards indicate their solubility for irrigation purposes. KR in almost all samples in water is within the permissible limit of irrigation standards. Higher MH values in all most all samples indicate the magnesium hazard of water which reduce the quality of soil and minimize the yield of the crops in the study area locations. The presence of bacterial species like *Klebsiella, Proteus, Enterobacter* and *E.coli* confirmed the microbial contamination of water which can cause water borne diseases like Cholera, Typhoid. Hence, the water is to be properly treated by the available treatment methods to minimize TDS, TH and chloride levels in water. Magnesium hazardous is controlled by the reduction of Mg^{2+} ion concentration by using Mg-Al oxide. Microbial contamination can be removed by disinfection and sterilization to protect the health of the public who consume the water in the study area.

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