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Research Article

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Physicochemical, Metal and Microbial Analysis of Sago Industry Effluent and nearby Ground Waters to Assess the impacts of Effluent on Ground waters

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ABSTRACT

Water sources near Industrial areas are generally exposed to pollution due to the effluents generated from the industrial units. Sago industry is a small scale industry and also a seasonal industry operating from September to March in East Godavari District. The washed residue of sago when released in to the nearby streams along with waste water can cause serious environmental problems. The present study is aimed to characterize the effluent and ground water for physicochemical parameters viz., 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 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), Kellys's Ratio (KR) and Magnesium hazard MH are determined to assess the suitability of waters 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 ion contamination .The higher values of EC, TDS, TA, Na, Chloride indicate the contamination of ground waters in the study area. Higher values of Magnesium Hardness indicate the (MH)of water which in turn deplete the quality of soil and consequently the crop yield will be reduced, if the waters are used for irrigation purposes. The lower metal ion concentrations indicate that the waters are free from metal toxicity. The water samples are also tested for MPN count and analyzed for identifying the bacterial species. Presence of pathogenic bacterial species viz., E.Coli, Enterobacter, Klebsiella and Pseudomonas indicate the bacterial contamination of waters and the waters can cause concern on human health, if consumed for drinking purposes. The waters are to be treated properly to protect the health of the public residing in the nearby habitations of the sago industry who consume these waters for drinking and domestic purposes.

Key words: Sago effluent, ground water, bacteria, metal ion, parameter

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INTRODUCTION

Water source are exposed to pollution due to its acceptability of effluents generated from various industrial units. The effluent is waste water treated or untreated which flows out of a treatment plant, sewer or industrial out fall. Sago industry is a small scale industry in India and is basically seasonal in nature, operating for only six months of the calendar year from September to March. Sago, the edible starch in the form of globules is manufactured from tapioca tubers (Manihotesculenta). The importance of starch production by sago palm is mainly focused in the Asia-Pacific region and South East Asia [1].The tapioca tubers are the raw material and are converted into commercial sago through indigenous technology which requires huge amount of water. During the process, about 45,000-50,000 litre of sago effluent is released and takes about 10 days for water to be let out of the factory as effluent[2],[3]. The generated effluent contains high content of organic load along with the effluent and when stored results in obnoxious odours, irritating colour, lower pH and higher BOD and COD [4]. When the effluent is released in to the environment without proper treatment, it can change the characteristics of ecosystem. The industrial effluents are generally considered harmful but sometimes used for irrigating various crops.[5],[6]**.**These waste waters contain higher concentration of dissolved and suspended solids with low pH, high BOD and COD which ultimately affect the quality of soil. Presently, these residues were washed off in to nearby streams together with waste water and deposited in the factory’s compound, which can lead to serious environmental problems, and the problems of pollution from sago starch processing are more social and economic in nature than technological. Most of the solid wastes and waste waters are discharged into the soil and water bodies and thus ultimately facade a serious threat to human and routine functioning of ecosystem [7].

Keeping in view the existence of significant number of sago industrial units in East Godavari District, it is proposed to characterize the effluent generated from sago industry and the ground water samples collected from the nearby areas of sago industry to evaluate the impact of effluent on ground water and to evaluate the quality of ground waters for considering them for utility.

EXPERIMENTAL SECTION

The ground water samples are collected towards East, West, North and South directions around the sago industry by considering the industry as nucleus at a distance of 0-1 km,2-3 km and 3-5 km and the details of sampling locations and its coordinates are presented in table-1

Table-1: Details of Sampling Locations distance from the source

Sl.no	Location	Source	Distance	GPS-Coordinates
SG-1	Nearby Sago industry	BW	E(0-1km)	N-170 01’ 842’’ E-820 08’ 937’’
SG-2	Balusulapeta,	BW	E (2-3km)	N-170 01’ 972’’ E-820 09’ 248’’
SG-3	Vetapalem(Near Paddy fields)	OW	E (3-5km)	N-170 01’ 390’’ E-820 08’ 645’’
SG-4	Hussainpuram(Jagannapeta)	OW	W (0-1km)	N-170 02’ 140’’ E-820 09’ 034’’
SG-5	Jagannapeta (Near rail way track)	OW	W (2-3km)	N-170 02’152 ’’ E-820 09’ 038’’
SG-6	Towards ADB road(Near RAK ceramics)	OW	W (3-5km)	N-170 01’234’’ E-820 09’138 ’’
SG-7	Towards Samalkota (Near Sugar industry lab)	BW	N (0-1km)	N-170 01’ 951’’ E-820 09’ 134’’
SG-8	Towards Samalkota(Sugar industry staff quarters)	BW	N (2-3km)	N-170 02’ 312’’ E-820 09’ 614’’
SG-9	Towords samalkota(Near Bheemeswara swami temple)	OW	N (3-5km)	N-170 02’ 536’’ E-820 10’ 047’’
SG-10	Hussianpuram(Near Ramakrishna fireworks)	BW	S (0-1km)	N-170 01’ 831’’ E-820 08’ 845’’
SG-11	Vetapalem(Near Adilaxmi industries)	OW	S (2-3km)	N-170 01’ 460’’ E-820 08’ 367’’
SG-12	Vetapalem (Mokkaraichettu)	OW	S (3-5km)	N-160 57’ 933’’ E-820 12’ 814’’

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

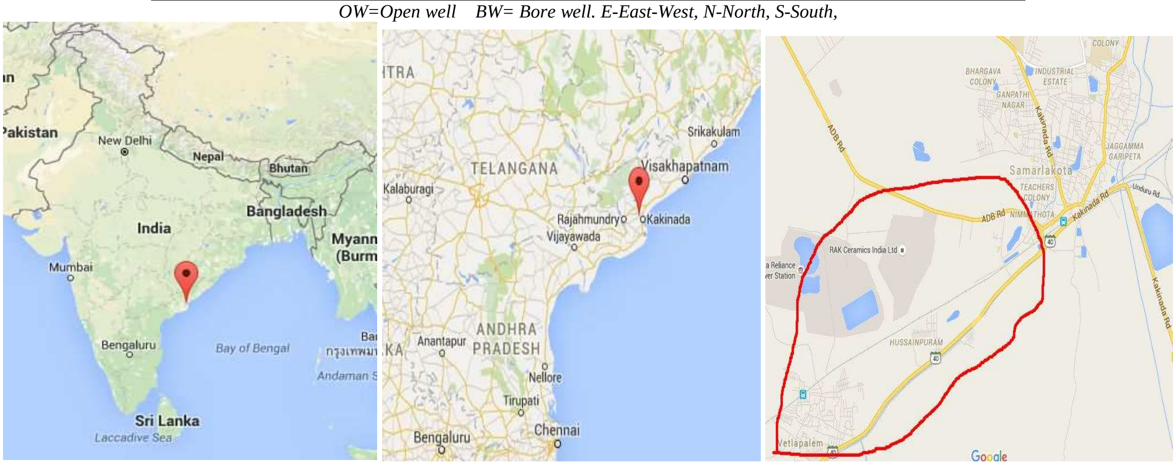


Fig-1: Maps showing the Study Area

Polythene containers were employed for sampling and preserved for analysis by following the standard procedures.[**8**].The samples were analysed 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 by Spectrophotometer (Model-167, Systronics), Na^+ and K^+ by Flame Photometer (Model-125, Systronics).The irrigation parameters determined for the waters 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

Percent Sodium (%Na) = $\frac{Na^{+} X100}{Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}}$ (meq/l)

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

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

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

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

The metal ion concentrations are analyzed by Inductive coupled Plasma Mass Spectrometry (ICPMS) technique Model-7700 Make- Agilent Technologies.

Microbial Analysis: The ground water samples are collected in sterilized containers [9] and immediately processed for analysis for determining the MPN count and for detecting the bacterial spps. The Most Probable Number (MPN) technique has been employed for the enumeration for the *Coliform* count in water samples [**10**],[**11**] which involved the presumptive test using lactose broth and Nutrient Agar, confirmatory test using Eosin Methylene Blue (EMB) agar, pure colonies of the isolated were subjected to grams stain, motility, Indole, Methyl red, Voges-Proskuer test, Citrate utilization test, Urease test, Catalase and Oxidase test.[**12**]

RESULTS AND DISCUSSION

The analytical data related to physicochemical and irrigation parameters are presented in Table-2&3.

Table-2: Physicochemical characteristics of Sago effluent and ground water

S.No	pH	EC µmhos/cm	TDS (mg/l)	TA (mg/l)	HCO_3^- (mg/l)	CO_3^{2-} (mg/l)	OH^- (mg/l)	TH (mg/l)	Ca^{2+} mg/l	Mg^{2+} mg/l
Effluent	5.7	1190	761.6	700	BDL	854	BDL	1100	160	170.8
SG-1	7.3	2910	1862.4	130	130	BDL	BDL	890	32	197.64
SG-2	7.9	640	409.6	220	190	30	BDL	240	24	43.92
SG-3	7.9	1260	806.4	210	200	10	BDL	320	24	63.44
SG-4	7.7	6080	3891.2	380	350	30	BDL	600	124	70.76
SG-5	8	6300	4032	350	290	60	BDL	430	44	78.08
SG-6	7.6	906	579.84	180	170	10	BDL	430	60	68.32
SG-7	7.5	700	448	80	80	BDL	BDL	320	56	43.92
SG-8	7.9	1450	928	120	110	10	BDL	350	44	58.56
SG-9	7.9	645	412.8	120	110	10	BDL	360	20	75.64
SG-10	7.3	1650	1056	90	90	BDL	BDL	570	88	85.4
SG-11	7.5	1310	838.4	140	130	10	BDL	340	52	51.24
SG-12	7.9	1750	1120	280	250	30	BDL	280	20	56.12

**BDL: Below detectable Limit*

Table-3: Physicochemical characteristics of Sago effluent and ground water

S.No	Na+ (mg/l)	K+ (mg/l)	Chloride (mg/l)	Sulphate (mg/l)	Phosphate (mg/l)	Nitrate (mg/l)	%Na (meq/l)	SAR (meq/l)	RSC (meq/l)	Kelly's Ratio (KR)	MH
Effluent	42.84	2.38	375.77	139	24.6	0.796	7.897	0.57	BDL	0.09	63.07
SG-1	207.1	3.2	588.47	BDL	1.6	5.549	33.98	3.05	BDL	0.52	90.81
SG-2	68.99	0.21	24.815	BDL	0.3	0.68	38.86	1.95	BDL	0.64	74.54
SG-3	114.83	1.71	159.53	BDL	0.5	3.336	44.14	2.82	BDL	0.8	80.88
SG-4	844.7	68.7	985.51	231	1.1	1.52	72.95	15.1	BDL	3.1	47.73
SG-5	921.9	34.9	1563.3	225	6.9	1.312	81.1	19.5	BDL	4.75	73.95
SG-6	60.01	6.39	109.9	BDL	1.8	40.9	23.22	1.27	BDL	0.31	64.56
SG-7	43.62	0.31	70.9	BDL	1.1	32.24	23.08	1.07	BDL	0.3	55.65
SG-8	109.77	15.26	226.88	BDL	1.2	7.689	39.61	2.57	BDL	0.69	68.05
SG-9	29.56	33.71	60.265	BDL	1.5	20.23	13.97	0.68	BDL	0.18	85.82
SG-10	95.49	6.43	297.78	47	0.8	2.577	26.7	1.75	BDL	0.37	60.83
SG-11	114.17	1.87	177.25	BDL	0.7	42.64	42.39	2.71	BDL	0.74	61.19
SG-12	179.7	66	187.89	BDL	0.2	7.33	52.12	4.72	BDL	1.42	81.78

The analytical data related to metal ion concentration is presented in Table-3.

Table-4: Metal ion concentration of Sago Industrial effluent and ground Waters

	SG-Ef	SG-1	SG-2	SG-3	SG-4	SG-5	SG-6	SG-7	SG-8	SG-9	SG-10	SG-11	SG-12
Metal	ppm	ppm	ppm	Ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Li	9.152	0.000415	0.000359	0.000947	0.001873	0.000177	0.002617	0.000691	0.000699	0.000536	0.000631	0.000526	0.000987
Be	BDL	0.000011	BDL	0.00004	0.00002	BDL	BDL	BDL	BDL	BDL	0.00002	BDL	0.000056
Al	26.848	0.003931	0.004445	BDL	0.082315	0.015637	BDL	0.001627	0.002876	0.021108	0.000816	0.003205	0.003014
V	7.804	0.002914	0.007802	0.008938	0.002678	0.000289	0.01021	0.007377	0.003035	0.002777	0.002819	0.001259	0.001997
Cr	14.751	0.000163	0.000085	BDL	0.000304	0.000229	BDL	0.001982	0.000084	0.000528	0.000218	0.000133	0.000845
Mn	77.809	0.000466	0.004136	0.0293	0.087015	0.426761	0.000962	0.000451	0.001051	0.02353	0.000043	0.000277	0.026659
Fe	38.274	0.001948	0.004489	0.002334	0.289021	0.046592	BDL	0.000156	0.001748	0.016969	BDL	0.003939	0.004017
Co	BDL	0.000046	0.000029	BDL	BDL	0.000188	BDL	0.000058	BDL	0.000365	BDL	0.000014	0.000176
Ni	1.692	0.000432	0.000358	0.000196	0.001676	0.000573	BDL	0.000728	BDL	0.003034	0.000226	0.000284	0.869
Cu	142.429	BDL	BDL	0.001187	0.001121	0.000007	0.001244	0.000068	0.000161	0.000233	0.000375	BDL	0.000092
Zn	24.699	0.011298	0.002091	BDL	0.002636	0.007821	BDL	0.00367	BDL	0.009549	0.000372	0.009275	0.001888
As	0.049	0.000305	0.000613	0.015311	0.001878	0.000078	0.000822	0.000749	0.000117	0.000169	0.000218	0.000081	0.001858
Se	BDL	BDL	0.000213	0.000495	BDL	0.000766	BDL	0.002447	BDL	0.001277	BDL	0.000535	0.006371
Rb	16.361	0.004147	0.000739	0.018428	0.016849	0.002863	0.022916	0.006562	0.002074	0.000776	0.001904	0.000574	0.011022
Sr	1143.533	0.397945	0.782633	0.603415	0.624801	0.722996	1.784579	0.841483	0.609063	2.330932	0.689466	0.37557	0.407599
Ag	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.00006	BDL	BDL	BDL
Cd	0.046	0.000008	0.000009	BDL	BDL	0.000011	BDL	0.000011	BDL	0.000018	BDL	0.000005	0.000012
Cs	0.021	0.000028	0.000009	0.000016	0.000026	0.000016	BDL	0.00002	0.000083	0.000012	0.000069	0.00002	0.000023
Ba	279.087	0.145523	0.150918	0.085244	0.170207	0.055844	0.125684	0.115489	0.160739	0.180931	0.091574	0.06072	0.059247
Pb	0.995	BDL	BDL	0.001378	0.000259	0.000047	0.000002	BDL	BDL	0.000106	BDL	BDL	BDL

**SG-Ef: sago Effluent. SG: Ground water samples near Sago industry*

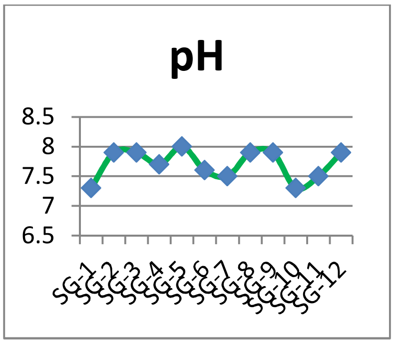
Table-5: Details of Cultural characterization and Bacterial species identified

Sample code	MPN Count/100ml	No.of Bacterial Colonies	Bacterial colony morphology on EMB	Gram Stain	Motility	Biochemical Tests							Bacteria identified
						Indole	MR	VP	Citrate	CA	OX	UR	
SG-EF	>1800	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*
			Pink Mucoid	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
SG-1	33	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*
SG-2	>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*
SG-3	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*
SG-4	>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*
SG-5	>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*
SG-6	>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*
SG-7	540	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*
			Pink Mucoid	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
SG-8	9	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*
			Pink Mucoid	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
SG-9	<2	1	Purple Centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
SG-10	2	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*
SG-11	<2	1	Colorless	-ve	Motile	-ve	-ve	-ve	-ve	-ve	+ve	-ve	*Pseudomonas*
SG-12	>1800	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*
			Pink Mucoid	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*

The collected water samples are analyzed for the microbial species and the data is presented in Table-5.

The Physicochemical parameters are also represented graphically in figures from 3-16

Fig-3-16: Graphical representation of physicochemical parametric values of Ground Water



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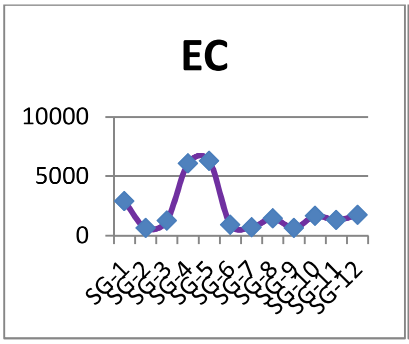

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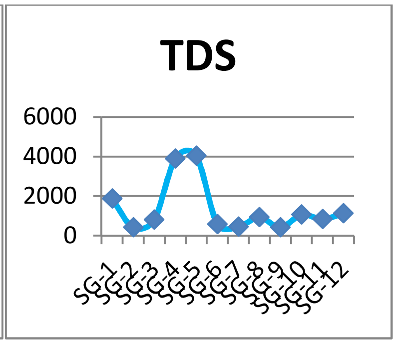

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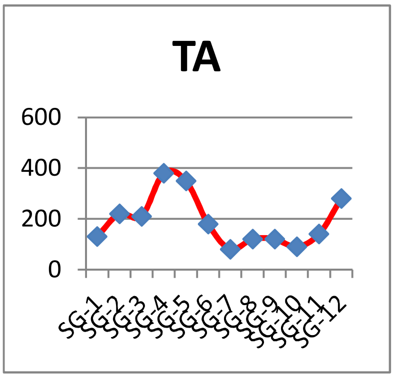

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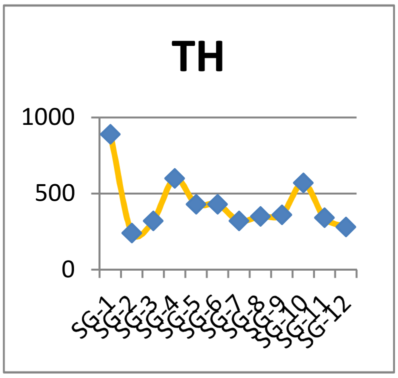

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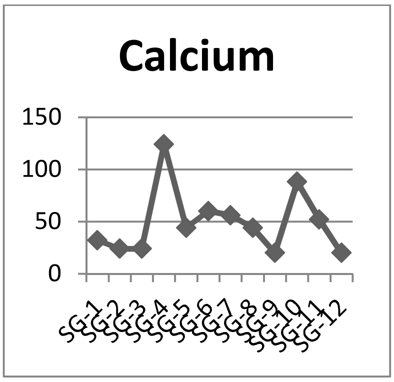

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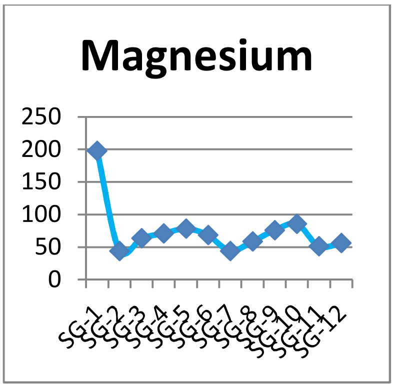

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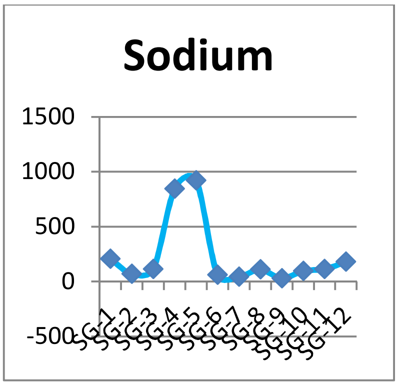

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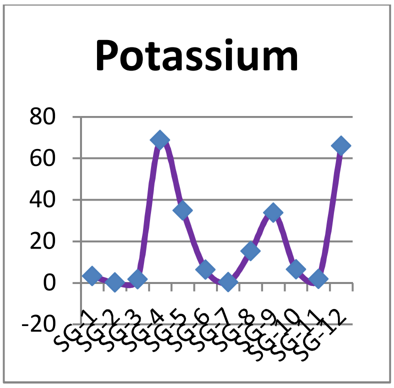

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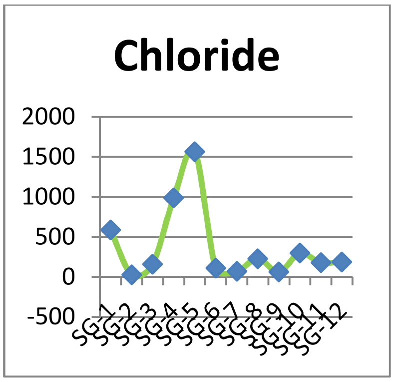

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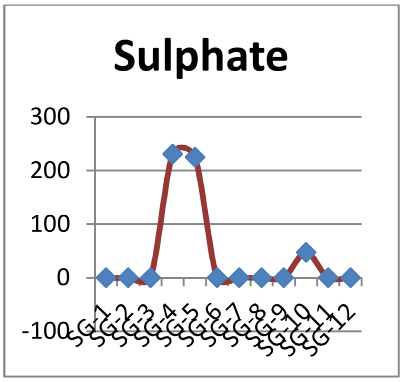

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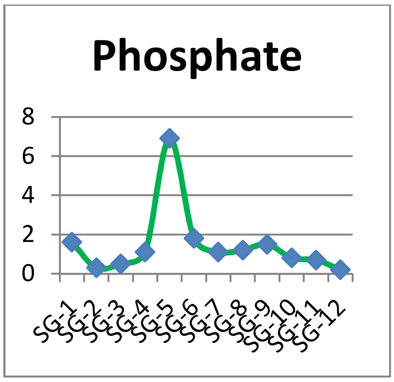

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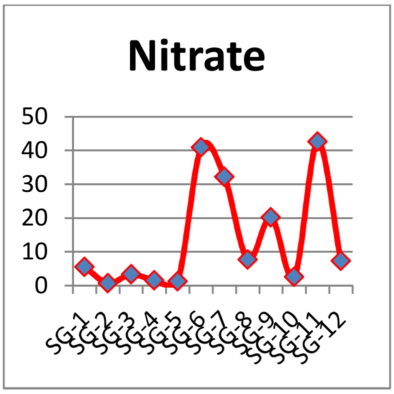


Fig-16

The Irrigation parametric values are represented graphically in figures from 17-20

Fig: 17-20: Graphical representation of irrigation parameter values

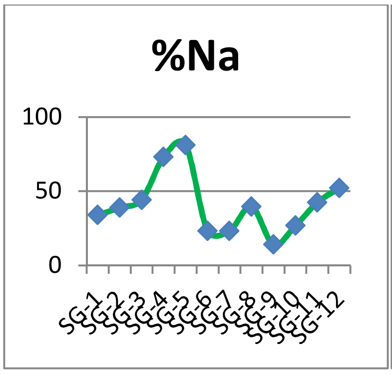


Fig: 17

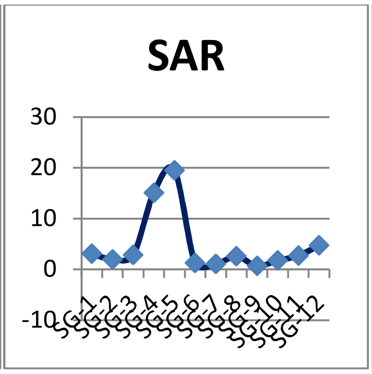


Fig: 18

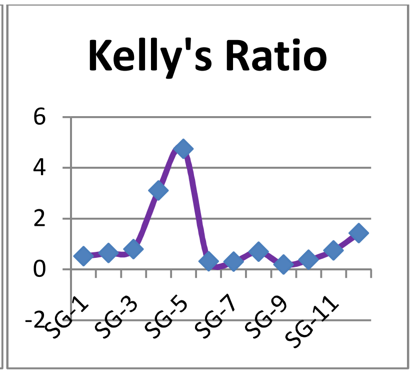


Fig: 19

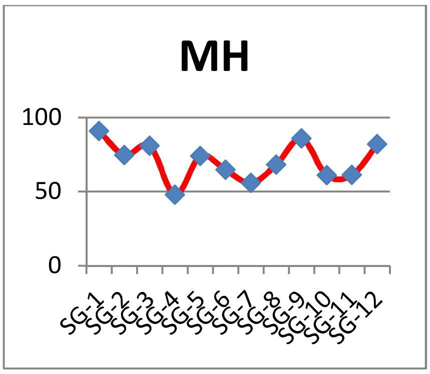


Fig: 20

pH: pH of Effluent is observed at 5.7 indicating acidic nature while pH of ground waters range from 7.3 to 8.0 indicating slight alkaline nature. The values indicate that there is no impact of effluent on groundwater quality in the nearby areas of the industry

Electrical Conductivity (EC): EC of effluent is recorded on 1190 µmos/cm while the EC of ground water range from 640-6300 µmos/cm EC of sample SG-4,5,6,7,8,9, and 12 range from 1310-1600 indicating the impact of effluent on ground water quality by enhancing EC, while in other samples EC has no impact.

Total dissolved Solids(TDS): TDS of effluent is observed as 867 mg/L.TDS of ground water samples ranges 448-3891.2 mg/L.TDS of samples SG-4,5,6,7,9,10 exceeded the TDS value of effluent indicating the impact of effluent on the water enhancing the normal TDS of 500 mg/L in the study area .The exceeded values indicate not only the impact of effluent but also on other factors which can cause concern on the surroundings

Total alkalinity (TA): Total alkalinity of effluent is observed as 320 mg/L which exceeded the permissible value of 200 mg/L indicating the alkaline nature of the effluent .TA of ground water samples range from 80-380mg/L.TA of Samples SG-2, 6, 7, 10, 12 exceeded the permissible level of drinking water standards and the higher values indicate the impact of effluent on ground water quality in the study area.

Calcium (Ca^{2+}): Calcium concentration of effluent is 432 mg/l and crossed the permissible limit of effluent standards 187mg/L. The permissible limit of Calcium in drinking water is 75 mg/L. Calcium in samples SG-5 and 6 exceeded the limit of drinking standards indicating the impact of effluent on ground water while in case of other ground water samples the impact of effluent is absent.

Magnesium(Mg^{2+}): Magnesium concentration of the effluent is 200mg/L and crossed the permissible effluent standard 123mg/L. Magnesium concentration in ground water ranges from 43.92mg/L -197.64 mg/L and the values crossed the drinking water standards of 30mg/L indicating the magnesium hardness of water.

Sodium(Na^{+}): Sodium ion concentration of effluent is 22mg/L and in groundwater ranges from 4.56-114.83 mg/L and the levels are below the permissible limit of WHO standards.

Potassium (K^{+}): Potassium ion concentration of effluent is at BDL while potassium ranges from 0.21-68.7mg/L.
Chloride: Chloride ion concentration range from 24.815 to 1563.3mg/l. In case of water samples SG-2, 3, 6, 7, 8, 9, 10, 11 and 12 the impact of effluent on ground waters is absent while in case of samples SG-1, 4, 5 the concentration are higher compared to the Chloride ion concentration in effluent. The higher values of chloride are the contribution of effluent due to the bleaching of effluent before letting out it into the environment.

Sulphate: Sulphate ion concentration of effluent 139 mg/L and is below than the effluent standards (208 mg/L). Sulphate concentration in ground water in samples SG-5,6,12 are within the permissible limit of drinking water while in other samples sulphate ion is at BDL.

Phosphate: Phosphate ion concentration of effluent is 24.6 mg/L Phosphate ion concentration in ground water range from 0.2-6.9 mg/L and the values indicate the absence of impact of effluent on ground water quality

Nitrate: Nitrate ion concentration in ground water ranges from 0.0680-40.90mg/L and are within the permissible limit of drinking water standards (45mg/L).The nitrate ion concentration in sago industrial effluent is 0.796 mg/L.The values indicate the absence of impact of sago effluent on ground water quality in the study area.

% Na: % Na of ground water range from 13.97-72.95 meq/L. In case of ground water samples SG-6 and SG-12, it crossed the limit of irrigation standard (60meq/L) and can cause concern on ground water quality. In case of all other samples %Na is within the permissible limit.

SAR: SAR of ground water range from 0.68-19.5 me/L all the levels are within the permissible limit (26me/L) of irrigation standard.

RSC: Residual Sodium Carbonates (RSC) of ground water are observed at BDL and are within the irrigation standards of water.

Kelly's Ratio: Kelly's ratio of ground water ranges from 0.3-4.75.Kelly's ratio of ground water samples SG-6, 7, 12 crossed the permissible limit of irrigation standard (1) while KR of the remaining water samples is within the permissible limit.

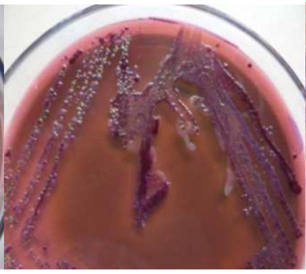
Magnesium Hazard: Magnesium hazard of water ground water ranges from 47.73-90.81 and the levels crossed the permissible limit of irrigation standards (50) indicating the magnesium hardness of water which can deplete the soil quality in the study area.

Metal ion concentration: The concentration of metal ion Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Ag, Cd, Cs, Ba and Pb are within the permissible limits of drinking waters indicating the absence of metal toxicity of waters in the study area.

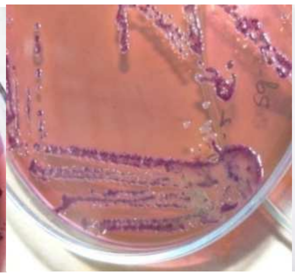
Microbial species: The waters are observed with *E-Coli* which indicates the microbial contamination of eaters in the study area. The waters are further analyzed for bacterial species and the presence of the pathogenic Bacteria Viz., *E-Coli, Enterobacter, Klebsilla,* and *Pseudomonas* can cause water borne diseases and show impacts on human health. The images of *bacterial species* identified in water samplesare represented in figuresS-E and SG-1 – SG-12

Fig-S-E and SG-1 – SG-12: Images of bacterial Spps in effluent and ground water samples

S- E
(*E.Coli, Enterobacter,Klebsilla)*



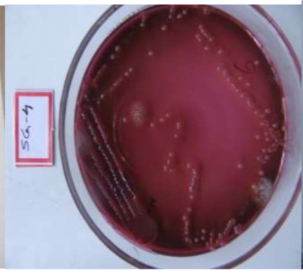
SG-1
(E.Coli,Enterobacter,Klebsilla)



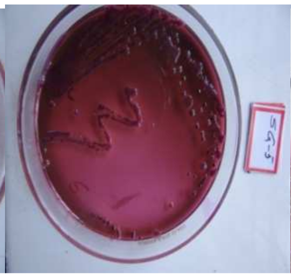
SG-2
(E.Coli,Enterobacter)

SG-3
(Enterobacter)

SG-4
(E.Coli, Enterobacter, Klebsilla)



SG-5
(Enterobacter, Klebsilla)



SG-6
(E.Coli, Enterobacter)

SG-7
(E.Coli,Enterobacter,Klebsilla)

SG-8
(Pseudomonas)

SG-9
(Enterobacter, Klebsilla)

SG-10
(Enterobacter, Klebsilla)

SG-11
(E.Coli, Enterobacter, Klebsilla)

SG-12
(E.Coli, Enterobacter, Klebsilla)

CONCLUSION

pH values of waters are within the permissible limit of drinking water standards. Higher values of EC, Na and Chloride in majority of samples indicate the saline nature of waters. Higher values of TDS in majority water samples indicate the presence of soluble solids in ground waters. Higher values of TA in water samples can change the taste of the waters. Higher values of Chloride concentration in water samples is due to the bleaching process of effluent during treatment and its impact on ground waters of very nearby locations to the industrial unit. The parametric values of sulphate are below the permissible value of drinking water standards. Nitrate and Phosphate levels are also within the permissible limit of drinking water standards indicating the non discharge of agricultural runoffs into the ground waters in the study area. Irrigation parametric values %Na, SAR, RSC and KR in almost all water samples are within the permissible limit indicating the suitability of waters for irrigation purposes, however MH values exceeded the permissible limit indicating the Magnesium Hazard of waters which can deplete the quality of soil and in turn the yield of the crops will be reduced in the study area. Lower concentration of metal ions indicate the non metal toxicity of waters in the study area. The presence of MPN count indicate the microbial contamination of waters and the presence of pathogenic bacterial spps viz., *Klebsilla, enterobacter, Pseudomonus*can cause water borne diseases, if these waters are consumed for drinking purposes. The research results revealed that the ground waters in the study area are chemically and microbially contaminated. Hence the waters are to be treated properly before considering the waters for use for drinking or domestic purposes.

Acknowledgement
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