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Physicochemical and Biochemical Characterization of Ground waters near point Sources for Assessing their Quality for user End Application

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ABSTRACT

The present proposal research study is mainly focused on evaluation of quality of ground waters around Sugar and Sago industrial units (Point Sources) to assess their potential for end use applications. The study includes the characterization of ground waters collected during pre and post monsoon seasons for physicochemical parameters viz., pH, Electrical Conductivity(EC), Total Dissolved Solids(TDS), Total Hardness(TH), Total Alkalinity(TA), Calcium(Ca^{+2}), Magnesium(Mg^{+2}), Sodium(Na^{+}), Potassium(K^{+}), Fluoride(F^{-}), Chloride(Cl^{-}), Sulphate(So_4^{-2}), Nitrate(No_3^{-}) and Phosphate(Po_4^{-3}) for estimating the chemical contamination status. Irrigation parameters like Percent Sodium(%Na), Sodium Adsorption Ratio(SAR), Residual Sodium Carbonate(RSC), Magnesium Hazard(MH) and Kelly's Ratio(KR) are also determined to verify the quality of ground waters for utilization for irrigation purposes. The parametric values of groundwater near sugar industry pH, EC, TDS, TA, Ca^{+2}, K, So_4^{-2}, No_3^{-} are observed at higher levels compared to the ground waters collected around sago industrial unit. The parametric levels TH, Cl^{-}, Mg^{+2}, Po_4^{-3} in waters near Sago Industry are comparatively higher than the parametric values of ground waters near Sugar industrial unit. Dissolved Oxygen(DO) levels of groundwater are observed at BDL near sugar industries while the DO levels of ground waters near Sago industry are observed at 1.7mg/l. Majority of parametric values of ground waters near sugar industrial unit indicate the higher levels of chemical contamination of waters Sugar Industry compared to the waters near sago industry. DO levels indicate their unsuitability for utilization of these waters for aqua cultural purposes. The physicochemical parametric values indicate that the contamination of ground waters near sugar industry are higher than the contamination of ground waters near sago industry. The irrigation parametric values viz., %Na, SAR, Kelly's Ratio are within the permissible limits of irrigation standards while the RSC and MH values are higher than the permissible limits of irrigation standards. Ground waters near both industrial units were analyzed for bacteria and the research results revealed that the ground waters were identified not only with MPN count in majority groundwater samples but also with other pathogenic bacterial species like E.Coli, Klebsiella, Pseudomonas, Proteus and Enterobacter indicating the bacterial contamination of ground waters near both the industrial units. The research results confirmed the unsuitability of the ground waters near both the industrial units for drinking and domestic purposes. The waters are to be properly treated even for consideration for irrigation purposes or otherwise the higher levels of Magnesium Hazard levels deplete the soil quality and consequently the crop yields will be minimized.

Keywords: Ground water, Industrial area, Quality, Drinking, Bacteria, health.

INTRODUCTION

Ground water contamination is mainly contributed by industrialization and urbanization and leads to environmental consequences. Point sources and relatively localized activities such as industrial waste, leaking waste containment facilities, leakage of underground storage tanks, the intersection of surface and groundwater are sources of pollution. Though industrialization contributes economical development, most important natural resources like water and soil are commonly polluted with waste material which in- turn effect the agriculture production and food security. Polluted soil and water also act as secondary source of pollution [1]. Sugar factories that operate about 4 to 8 months in a year produce huge quantity of waste matter and it pollute water and soil. According to National Federation of Cooperative Sugar Factories Ltd (NFCSFL) about 160 sugar factories in Maharashtra release harmful waste matter in the surrounding [2]. Pondhe, G.M. et al., studies revealed that the effluents of sugar factory percolate in the soil and reach the ground water table and affect its quality by changing its chemical composition [3]. The studies of Nomulwar Poonam and P.M. Patil in Wardha district of Maharashtra revealed that the sugar industrial effluents effect on irrigation process [4]. Once the groundwater is contaminated its quality cannot be easily restored back and to device ways and means to protect it [5]. The studies of Elizabeth et al., revealed that water borne diseases cause health hazards [6].

Keeping in view the importance of water in our daily life, there is need to carry out physicochemical and microbiological characterization to check the water quality for confirming that it is free from disease causing microorganisms and chemical contamination which causes concern on health[7] .The research studies of Shama et al., revealed that the quality of water is of vital concern for the mankind as it directly effects human welfare [8]. The Sago factory effluent discharged as wastewater carries various toxic chemicals that pollute water and air. Untreated effluents are highly toxic to the plants, fishes and other aquatic organisms, sulphide and at higher pH in the effluents cause concern on environment [9, 10]. The effluent released from the sago industry when stored results in obnoxious odours, irritating colour, lower pH and higher BOD and COD [11] and without proper treatment, if released into the environment, it adversely affect the ecosystem by altering its characteristics. Keeping in view the existence of habitations nearby areas of Sugar and Sago Industrial units (Point Sources) in East Godavari District attempts have been made on characterization of Ground Water samples analysis to assess the potential of ground waters for evaluating its quality by Physicochemical and Biochemical characterization consider for user end application.

MATERIALS AND METHODS

East Godavari region which is situated along the northern coast of Andhra Pradesh and the study areas are located in between the latitudes $17^0 03^1$N and longitude $82^0 13^1$E in respect of Sugar Industry and the latitudes $17^0.4^1$N and longitude $82^0.03^1$E in respect of Sago Industry . Ground water samples collected around the Sugar and Sago industries as centre and at a distance of 0.5,1 and 2km to each side of East, West, North, South directions. Sampling was done in Pre Monsoon and Post Monsoon seasons the details of sampling code and the sampling locations are presented in Table-1 and the study area Map is presented in figure1.

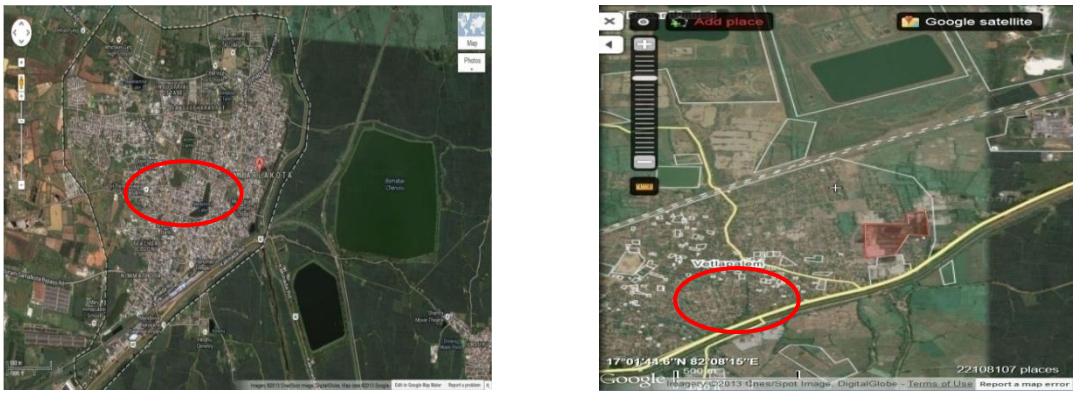


Figure-1 Study Area Maps

Table-1: Sample code and Sampling location

Sample Code	Direction	Distance	Near Sugar Industry	Near Sago Industry
GW-1	East	0.5km	Temple	Near sago industry
GW-2		1.0km	Cattle Shed	Cattle shed
GW-3		2.0km	Cattle Shed	Residential House
GW-4	West	0.5km	Hussanpuram	water Tank
GW-5		1.0km	Residential House	SC Colony
GW-6		2.0km	Durga Fancy Shop	2km away from colony
GW-7	North	0.5km	MaryImmaculateH.School	Manikanta sago
GW-8		1.0km	Satyanarayanapuram	Rice Mill
GW-9		2.0km	Samalkot 15th ward	Old well
GW-10	South	0.5km	Katakamvari veedhi	Panchayat Office
GW-11		1.0km	Sampangithota veedhi	Anganvadi Kendra
GW-12		2.0km	Opposite Register Office	Medapadu Bridge

Containers made of polythene were employed for sampling of ground water and preserved for analysis as per the standard procedures [12]. Twelve ground water samples were collected near each Industry and analyzed for physicochemical parameters which include pH, EC, TDS, TA, TH, Ca, Mg, 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 calibrated from the relation TDS= Electrical conductivity(EC) x0.64. Total Hardness, Total Alkalinity and Chloride were estimated by Titrimetry. Sulphate, Nitrate and Phosphate measured by Spectrophotometer (Vissican167, Systronics), Na and K by Flame photometry (Systronics). The average value of each parameter characterized during pre monsoon and post monsoon periods were calculated and in turn the average was considered as the parametric value for each parameter.

Bacterial Analysis: The ground water samples were collected in sterilized containers [13] and immediately transported to the laboratory for the bacterial analysis. The Most Probable Number (MPN) technique was employed for the enumeration for the C*oliform* count in water samples [14,15] . This 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 tests, Urease test, Catalse and Oxidase tests [16]. The ground water samples were analyzed for physicochemical parameters and the analytical data is presented in table 2

Table 2. Characteristics of ground water near Sugar and Sago industries

S.No.	Parameter	Industry	
		Sugar	Sago
1	pH	8.0	7.7
2	EC(µmhos/cm)	1780	1106
3	TDS(mg L^{-1})	1140	701
4	TH(mg L^{-1}	1508	1662
5	TA(mg L^{-1})	796	571
6	F^-((mg L^{-1})	0.65	0.65
7	Cl^- (mg L^{-1})	159.5	247
8	So_4^{-2} (mg L^{-1})	119	101
9	No_3^- (mg L^{-1})	22	11.5
10	Po_4^{-3} (mg L^{-1})	3.8	11.4
11	Na(mg L^{-1})	56	57
12	K(mg L^{-1})	29.7	19
13	Ca(mg L^{-1})	72	118
14	Mg (mg L^{-1})	324	330
15	DO(mg L^{-1})	BDL	1.7

The irrigation parameters Viz., Percent Sodium(%Na), Sodium Adsorption Ratio(SAR), Residual Sodium Carbonate(RSC), Magnesium Hazard(MH), Kelly's Ratio(KR) were calibrated, by employing the following relationship

Percent Sodium values are expressed in meq L^{-1}

$$\%Na\ (meq\ L^{-1}) = \frac{Na \times 100}{Na+K+Ca+Mg}$$

Sodium Adsorption Ratio values are expressed in meq L^{-1}

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

Residual Sodium Carbonate values are expressed in meq L^{-1}.

$$RSC\ (meq\ L^{-1}) = (Co_3^{-2}+HCo_3^-) - (Ca^{+2}+Mg^{+2})$$

Magnesium Hazard values are expressed in meq L^{-1}.

$$MH = \frac{Mg \times 100}{Ca+Mg}$$

Kelly's Ratio values are expressed in meq L^{-1}.

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

The data related to irrigation parameters is presented in table-3

Table 3. Irrigation Parameters

S.No.	Parameter	Type of Industry	
		Sugar	Sago
1	%Na (meq L^{-1})	12.7	11.35
2	SAR (meq L^{-1})	0.7	0.85
3	RSC (meq L^{-1})	7.16	1.44
4	MH	79.8	72.4
5	Kelly's Ratio(KR)	0.18	0.15

The graphical representations of Physicochemical and Irrigation parameters of ground waters near Sugar and Sago Industries are presented in figures 2 and 3 respectively

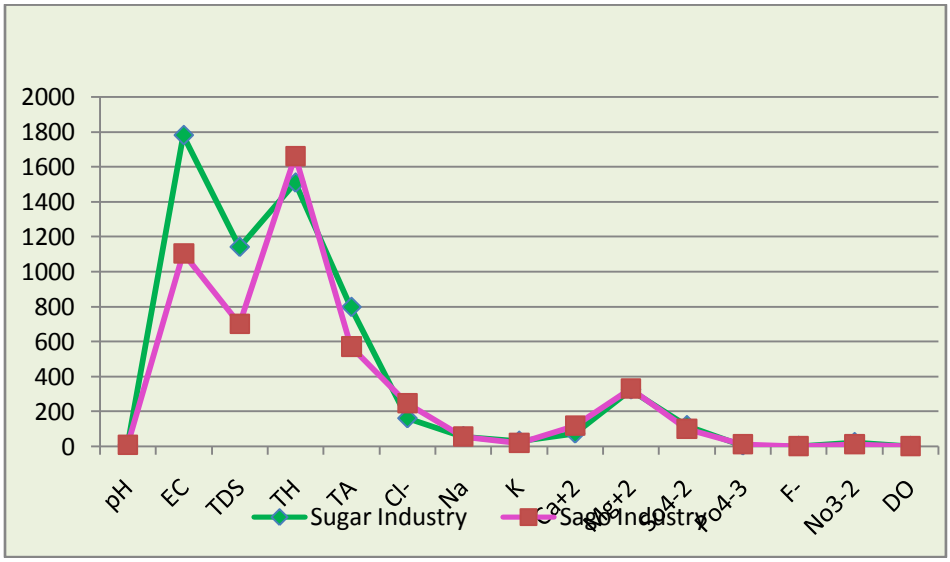


Fig 2. Physicochemical characteristics of ground waters near Sugar and Sago Industries

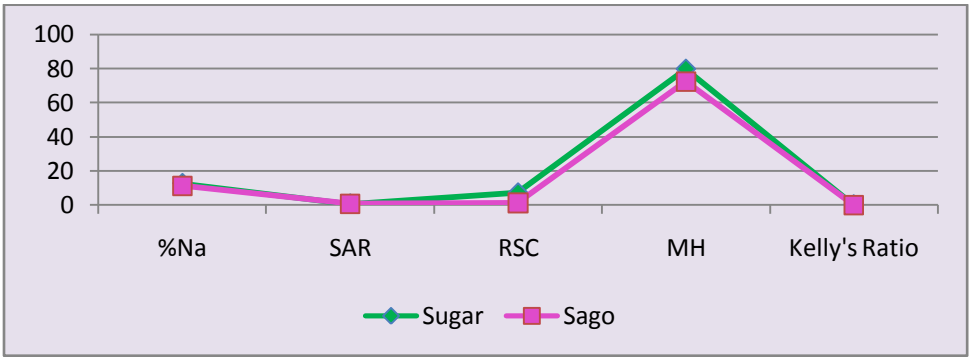
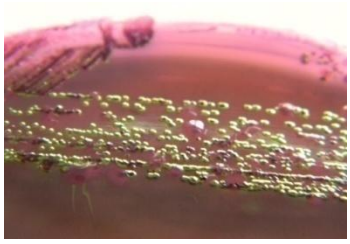


Fig-3: Irrigation parameters of ground waters near Sugar and Sago Industries

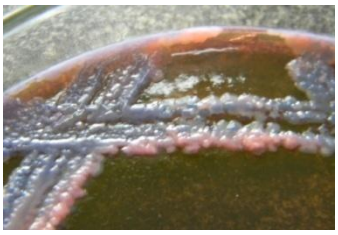
Further Ground waters were collected near the two Industries and were analyzed for bacterial Species and details of the microbial data is presented in tables 4 and 5 respectively. The Microbial species identified in Pre Monsoon and Post Monsoon period groundwater samples are presented in figure-4(a),(b),(c),(d), (e) and 5(a),(b),(c),(d) and (e) respectively

Table-4: Details of the Microbial Analytical data of Groundwater near Sugar Industry

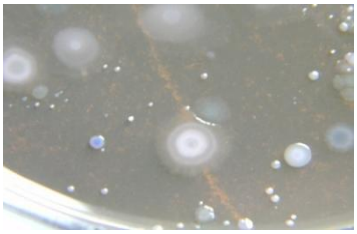
Sample Code	*Bacterial Species* Identified											
	MPN Count/100ml		*E coli*		*Klebsiella*		*Pseudomonas*		*Proteus*		*Enterobacter*	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	Post	pre	Post	pre	Post	pre	Post	pre	Post	Pre	Post
GW-1	0	26	- ve	-ve	- ve	- ve	+ ve	+ ve	+ ve	+ve	- ve	- ve
GW-2	95	110	+ ve	- ve	+ ve	+ve	- ve	+ve	+ ve	+ ve	- ve	- ve
GW-3	140	220	+ ve	+ ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-4	0	17	- ve	+ve	- ve	- ve	+ ve	+ ve	+ ve	+ ve	- ve	- ve
GW-5	79	110	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-6	40	130	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-7	0	0	- ve	- ve	- ve	-ve	+ ve	+ ve	- ve	+ ve	- ve	- ve
GW-8	1800+	900	+ ve	- ve	+ ve	+ ve	- ve	- ve	- ve	- ve	+ ve	- ve
GW-9	26	22	- ve	- ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-10	17	40	+ ve	- ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-11	45	170	- ve	-ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-12	920	280	+ ve	+ ve	+ ve	+ ve	- ve	- ve	- ve	-ve	- ve	- ve



4a.*E.Coli*

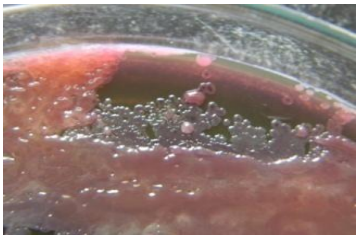


4b. *Klebsiella*



4c.*Proteus*

4d. *Pseudomonas*

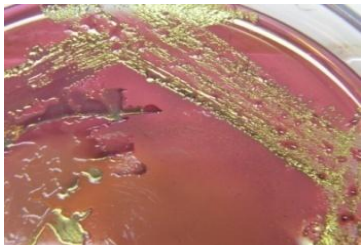


4e. *Enterobacter*

Figure-4: *Bacterial Spp*s identified in waters near Sugar Industrial Unit.

Table-5: Details of the Microbial Analytical data of Groundwater near Sago Industry

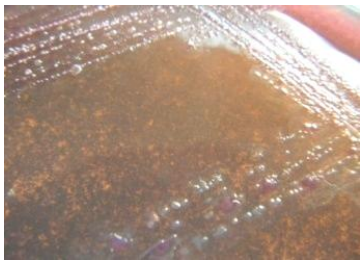
Sample Code	*Bacterial Species* Identified											
	MPN Count/100ml		*E coli*		*Klebsiella*		*Pseudomonas*		*Proteus*		*Enterobacter*	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	Post	pre	Post	Pre	Post	pre	Post	pre	Post	Pre	Post
GW-1	45	80	+ ve	+ ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-2	47	130	+ ve	+ ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-3	350	240	- ve	+ ve	+ ve	+ ve	- ve	- ve	+ ve	- ve	+ ve	- ve
GW-4	170	300	+ ve	+ ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-5	180	220	- ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	+ ve	+ ve
GW-6	920	350	+ ve	+ ve	- ve	- ve	- ve	- ve	+ ve	- ve	- ve	- ve
GW-7	110	230	+ ve	+ ve	- ve	- ve	- ve	- ve	+ ve	+ ve	- ve	- ve
GW-8	11	7	+ ve	+ ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-9	180	300	+ ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-10	920	900	+ ve	+ ve	+ ve	+ ve	- ve	- ve	- ve	- ve	- ve	- ve
GW-11	220	170	- ve	+ ve	+ ve	+ ve	- ve	- ve	+ ve	- ve	+ ve	+ ve
GW-12	40	90	+ ve	+ ve	- ve	- ve	- ve	- ve	+ ve	+ ve	- ve	- ve



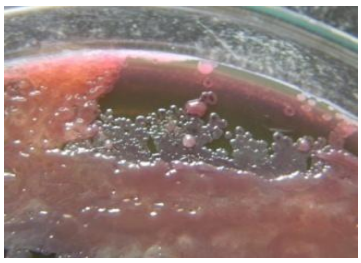
5a.*E.Coli*

5b.*Klebsiella*

5c.*Proteus*



5d. *Pseudomonas*



5e. *Enterobacter*

Figure-5: *Bacterial Spp*s identified in waters near Sago Industrial Unit

RESULTS AND DISCUSSION

pH: Water with pH in the range from 6.5-8.5 can be considered for drinking purposes. Water with pH value range between 6.5-8.4 can be used for irrigation without any problem and between 5.1-6.4 and 8.5-9.5 considered as moderate class [17]. Total Average value of pH during Pre and Post Monsoon seasons of Sugar Industry is 8.0 while the Total Average value of pH during Pre and Post Monsoon seasons of Sago Industry is 7.7. The pH of Groundwater samples near Sugar Industry is higher than the pH of groundwater samples near Sago Industry waters near both the Industrial units exhibit alkaline nature; however the alkalinity seems to be more in case of Ground waters near Sugar Industry compared to Sago Industry.

Electrical Conductivity (EC): Total Average value of EC during Pre and Post Monsoon seasons of Sugar Industry is 1780 µmhos cm^{-1}, while the Total Average value of EC during Pre and Post Monsoon seasons of Sago Industry is 1106.5 µmhos cm^{-1}. The EC levels in Ground water samples collected near both the Industry are at higher levels; however, EC of Ground waters of Sugar Industry can be classified as class-II waters and good for irrigation [18]; however harmful to sensitive crops.

Total Dissolved Solids (TDS): Total Average value of TDS during Pre and Post Monsoon seasons of Sugar Industry is 1140 mg/l , while the Total Average value of TDS during Pre and Post Monsoon seasons of Sago Industry is701mg/l. Both the TDS levels exceeded the permissible limit(500mg L^{-1}) [19] of drinking water standards and indicate the unsuitability of these waters for drinking and irrigation [18] purposes. While the TDS levels in Ground waters near Sago Industry can be classified as Class-II waters. Indicating that the Ground waters near Sugar Industry were contaminated to a greater extent compared to the waters near Sago Industry.

Total Hardness (TH): Total Average value of TH during Pre and Post Monsoon seasons of Sugar Industry is 1508 mg/l, while the Total Average value of TH during Pre and Post Monsoon seasons of Sago Industry is 1662 mg L^{-1}. The TH levels in water near both the Industries indicate the very hard nature of waters and their unsuitability for drinking as well as for domestic purposes. The higher levels of TH made the Ground waters to be with encrustation and cause impacts on water supply systems.

Total Alkalinity (TA): Total Average value of TA during Pre and Post Monsoon seasons of Sugar Industry is796 mg L^{-1}, while the Total Average value of TA during Pre and Post Monsoon seasons of Sago Industry is 571mg L^{-1}. The TA levels in waters near both the Industrial unit exceeded the permissible limit [19] of 200 mg L^{-1} and indicate the alkaline nature of the waters and the waters will lose taste and hence become unsuitable for drinking as well as for domestic uses.

Fluoride (F^-): Total Average value of F^- during Pre and Post Monsoon seasons of Sugar Industry is 0.65 mg L^{-1}, while the Total Average value of F^- during Pre and Post Monsoon seasons of Sago Industry is 0.65 mg L^{-1}. The fluoride levels are within the permissible limit [19] of drinking standards.

Chloride: The Permissible limit of Chloride in drinking wate is 250 mg L^{-1} [19]. Waters with Chloride levels in the range from 0-142mg L^{-1} were classified as Class-I waters and can be considered excellent for irrigation. Chloride levels in waters in the range from 142-355mg L^{-1} made waters as Class-II and were good for irrigation; however harmful for sensitive crops. Total Average value of Cl^- during Pre and Post Monsoon seasons of Sugar Industry is 159.5 mg L^{-1}, while the Total Average value of Cl^- during Pre and Post Monsoon seasons of Sago Industry is 247 mg L^{-1}. Near both the Industries the Chloride levels were observed within the range from 142-355mg L^{-1} and considered as Class-II and were good for irrigation; however harmful for sensitive crops.

Sulphate: Total Average value of Sulphate during Pre and Post Monsoon seasons of Sugar Industry is 119mg L^{-1}, while the Total Average value of Sulphate during Pre and Post Monsoon seasons of Sago

Industry is 101mg L^{-1} all are within the permissible limit of 200mg L^{-1} of drinking water standards [19]. The levels of Sulphate indicate that there are no impacts of industrial effluent on the Ground waters near both the Industries.

Nitrate: Total Average value of Nitrate during Pre and Post Monsoon seasons of Sugar Industry is 22 mg L^{-1} , while the Total Average value of TA during Pre and Post Monsoon seasons of Sago Industry is 11.5 mg L^{-1}. The values of Nitrate are within the Permissible limit [19] of drinking water standards.

Phosphate: Total Average value of Phosphate during Pre and Post Monsoon seasons of Sugar Industry is 3.8 mg L^{-1}, while the Total Average value of TA during Pre and Post Monsoon seasons of Sago Industry is 11.4 mg L^{-1}. The Phosphate levels in Ground waters near Sugar Industry are comparatively lower than the Phosphate levels in waters near Sago Industry.

Sodium (Na): Total Average value of Na during Pre and Post Monsoon seasons of Sugar Industry is 56 mg L^{-1}, while the Total Average value of Na during Pre and Post Monsoon seasons of Sago Industry is 57mg L^{-1}.

Potassium (K): Total Average value of K during Pre and Post Monsoon seasons of Sugar Industry is 29.7mg L^{-1}, while the Total Average value of K during Pre and Post Monsoon seasons of Sago Industry is 19 mg L^{-1}.

Calcium ($Ca^{)}$: Total Average value of Ca during Pre and Post Monsoon seasons of Sugar Industry is 72 mg L^{-1} and is below the Permissible limit (75mg L^{-1}) [19] while the Total Average value of Ca^{+2} during Pre and Post Monsoon seasons of Sago Industry is118 mg L^{-1} and the Calcium levels on higher than the Permissible limit (75mg L^{-1}) and can cause encrustation on water supply system and hence these waters were unsuitable for domestic use.

Magnesium(Mg): Total Average value of Mg during Pre and Post Monsoon seasons of Sugar Industry is 324 mg L^{-1}, while the Total Average value of Mg^{+2} during Pre and Post Monsoon seasons of Sago Industry is330 mg L^{-1}. The Magnesium levels in waters near both the Sugar and Sago Industry were higher than the Permissible limit [19] (70 mg L^{-1}) and the higher levels of Magnesium contributes Magnesium hazard to these waters and consequently the soil fertility will be depleted and the yield of the crops will be minimized.

Dissolved Oxygen (DO): Total Average value of DO during Pre and Post Monsoon seasons of Sugar Industry is BDL, while the Total Average value of TA during Pre and Post Monsoon seasons of Sago Industry is 1.7 mg L^{-1}. The lower values of DO indicate that these waters will not be utilized for agricultural purposes.

Percent Sodium (%Na): Total Average value of %Na during Pre and Post Monsoon seasons of Sugar Industry is 12.7 me/l, while the Total Average value of %Na during Pre and Post Monsoon seasons of Sago Industry is 11.35 meq L^{-1} and all these levels are within the permissible limit 60 meq L^{-1} [20] of irrigation standards these values indicate that Ground waters near both the Industries indicate that these waters can be utilized for Agricultural purposes.

Sodium Adsorption Ratio (SAR): Total Average value of SAR during Pre and Post Monsoon seasons of Sugar Industry is 0.7 meq L^{-1} While the Total Average value of SAR during Pre and Post Monsoon seasons of Sago Industry is 0.85 meq L^{-1}. The values of SAR in waters of both the Industries indicate that these waters can be used for irrigation purposes Ref- as the values of SAR within the Permissible limit of Irrigation standards (26 meq L^{-1}) [21] .

Residual Sodium Carbonate (RSC): Total Average value of RSC during Pre and Post Monsoon seasons of Sugar Industry is 7.16 meq L^{-1}, while the Total Average value of RSC during Pre and Post Monsoon seasons of Sago Industry is 1.44 meq L^{-1}. The RSC levels of Ground waters of Pre Monsoon near Sugar Industry is on the higher side of the Irrigation standards and hence can be treated as unfit for irrigation purposes [22]. While the waters with RSC (1.44 mg L^{-1}) which made the waters to be used cautiously for irrigation purposes.

Magnesium Hazard (MH): Total Average value of MH during Pre and Post Monsoon seasons of Sugar Industry is 79.8, while the Total Average value of MH during Pre and Post Monsoon seasons of Sago Industry is 72.4. The values of MH in ground waters near Sugar and Sago are higher than the Permissible limit [23] of 50 and hence these waters can cause Magnesium Hazard so that the waters can deplete the soil quality and consequently the crop yields will be minimized if these waters are employed for irrigation.

Kelly's Ratio (KR): Total Average value of KR during Pre and Post Monsoon seasons of Sugar Industry is 0.18 meq L^{-1}, while the Total Average value of KR during Pre and Post Monsoon seasons of Sago Industry is 0.15 meq L^{-1}. The Kelly's Ratio levels are within the Permissible limit [24, 25] of 1 and hence these waters can be considered for irrigation purposes.

APPLICATIONS

These results are useful to know the suitability of these water for various purposes.

CONCLUSIONS

The pH of ground waters near Sugar Industry (8.0) is higher than the pH of ground waters near Sago Industry (7.7) indicating more alkaline nature of waters near Sugar Industry compared to waters near Sago Industry. The parametric levels of EC, TDS, TH, and TA of waters near Sugar and Sago Industry crossed the permissible limits of IS: 10500-1992 indicating the contamination level and there by their unsuitability for drinking and domestic utility. However the contamination levels of ground waters near Sugar Industry are higher than the contamination of ground water near Sago Industry. Chloride levels in ground waters near Sugar Industry (159.5 mg L^{-1}) is within the permissible limit [19]while the Chloride level in ground waters near Sago Industry(247 mg L^{-1}) almost reaches the threshold limit (250 mg L^{-1}) indicating more saline nature. The parametric levels of sulphate, fluoride in waters near both the industrial units are within the permissible limits. Calcium concentration in ground waters near Sugar Industry (72 mg L^{-1}) [19] is within the permissible limit while Calcium concentration in waters (118 mg L^{-1}) near Sago Industry exceeded the permissible limit (75 mg L^{-1}) indicating the possibility of causing encrustation in water supply systems. Concentration of Sodium, in waters near both the industries are almost equal while the concentration of Potassium in waters near Sugar Industry (29.7 mg L^{-1}) is more than the concentration of Potassium (19 mg L^{-1}) in waters near Sago Industry. Magnesium concentration in waters near both the industries crossed the permissible limits indicating the Magnesium Hazard of the ground waters. Nitrate levels in ground waters near Sugar Industry (22 mg L^{-1}) is comparatively higher than Nitrate level (11.5 mg L^{-1}) but are within the permissible limit of 45 mg L^{-1} in ground waters near Sago Industry while the Phosphate level (3.8 mg L^{-1}) near Sugar Industry is lower than the phosphate levlel (11.4 mg L^{-1}) in waters near Sago Industry. Dissolved Oxygen in waters near Sugar Industry is observed at Below Detectable Limit (BDL) while its value is 1.7 mg L^{-1} in waters near Sago Industry. These levels indicate the unsuitability of these waters for aqua cultural purposes. The parametric values of irrigation parameters like Percent Sodium, Sodium Adsorption Ratio and Kelly's Ratio are within the permissible limit of irrigation standards indicating their suitability for irrigation purposes. Residual Sodium Carbonate value(RSC) of ground waters near Sugar Industry (7.16 mg L^{-1}) exceeded the permissible limit of irrigation standards[22] while RSC (1.44 mg L^{-1}) of ground waters near Sugar Industry indicate the usage of waters with proper precaution. Magnesium Hazard(MH) levels of ground waters near both Sugar and Sago Industries are

higher than 50 indicating the Magnesium Hazard of these ground waters and there by these waters deplete the soil quality and consequently the yield of the crops irrigated with these waters may decrease. The presence of bacterial species like *E.Coli, Klebsiella, Pseudomonas, Proteus and Enterobacter* in the ground waters near both the industries indicate the bacterial contamination and hence these waters are unsuitable for drinking as well as domestic purposes as they cause concern on human health. On comparison and based on higher chemical and bacterial contamination, the ground waters near both the industrial units are not suitable for drinking and domestic purposes. Further these waters are to be properly treated even for consideration for irrigation purposes.

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