Effect of Sugar Industry Liquid Waste on Ground Water and River Water in Gadarwara

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Abstract— River water and Groundwater, the main source of irrigation, drinking or domestic purposes, is affected due to discharge of industrial effluents. The sugar industry contain remnants of chemical used for processing like caustic soda, sodium chloride, lime, sulphur and softening agents etc. and have potential to cause groundwater quality deterioration. In order to assess the water quality index, water samples of various sources were collected from around the sugar mills placed at Gadarwara, Narsinghpur. Altogether four groundwater samples three river water sample were processed to detailed analysis of various parameters following the standard guideline of APHA, WHO study under investigation alarming pH ranges (6.8-8.6), 400-1350 mg/l of Ca2++Mg2+, and (234.3-468.4) ppm chloride concentrations were obtained might be certainly problematic for drinking purpose. Amongst the Physical & Chemical parameters water quality index (W.Q.I.) concentration found beyond the permissible limit (both the sugar mills, Shakti, Narmada) for irrigation and domestic purpose. Based on categorization of irrigation classes under the study indicated that the sources fall under either medium or high salinity hazards required special attention for irrigation and domestic purpose.

Key words: Physical and chemical water quality, Water quality index (W.Q.I.), Shakkar River, Gadarwara, Madhya Pradesh, India, W.H.O

I. INTRODUCTION

River is a natural source of water for house use, agriculture use, as well as industrial use. Generally, river water is fresh and safe for use. Water is a very good solvent and it can dissolve so many substances either they are organic or inorganic in nature. Quality of water is decided on the basis of its dissolved and suspended substances which are either useful or harmful for the growth of living organisms. Our work was aimed to know the water quality index of Shakkar River on Gadarwara, Narsinghpur district of Madhya Pradesh, India. He main factors responsible for increasing water pollution are exponential growth of population, urbanization, industrialization and agricultural revolution. Groundwater quality is affected due to discharge of poor quality water from various industries and urban wastewater to the natural water courses. The sugar industry contain remnants of chemical used for processing like caustic soda, sodium chloride, lime, sulphur and softening agents etc. which degrade the quality of ground water. During the last few decades, disposal of sewage-sludge without proper treatment from urban areas and effluents from industries have caused the deterioration in the quality of groundwater. The need has arisen to review and recognise environmental problems associated with sugar mills. The effluents discharged from the sugar factories, distilleries etc. introduced in to the groundwater might be causing undesirable qualities. Therefore, the present study has been carried out to assess the various quality parameters of ground water sample of different water bodies situated in the vicinity of sugar mills.

II. METHODS AND MATERIALS

A. Study Area

The Shakkar River is a tributary of the Narmada River in the state of Madhya Pradesh in central India. It meets Narmada near Gadarwara. The Shakkar River passes through 23.0°N 8.41°E and nearby towns are Pipariya, Bareli, Sohagpur, Gadarwara.

B. Selection of sampling site map

C. Sampling stations

Code Name	Site Name
A	Effluent from Shakti sugar mill Gadarwara
B	U/S Before mixing Shakkar river
C	D/S After mixing Shakkar river
D	Ground water taken from shallow well, Kodiya
E	Ground water taken from deep well, Kodiya
F	Effluent from Narmada sugar mill Gadarwara
G	Ground water taken from shallow well, Salichouka
H	Ground water taken from deep well, Salichouka

Table 1: Sampling station name and code name

D. Sampling and field work

Samples were collected as per the guidelines of APHA. Each sample was taken in clean plastic bottle and kept in iceberg on the field. Turbidity, Colour, Odour, Temperature, Total Suspended Solid, Oil & Greases, Alkalinity, Total Hardness, Calcium, pH, Total Solids, COD, DO, BOD, Chlorides, Fluorides, Sulphates, Phosphates were tested in a laboratory while BOD bottles were filled at site and reagents for DO

fixation were mixed at the time of sample collection. The Physical and chemical water quality analysis of samples was performed using standard analytical methods. All samples were transported to the Madhya Pradesh Pollution Control Board Jabalpur.

E. Methods

The physical & chemical water quality analysis of water samples was carried out using standard analytical methods as per the guidelines of APHA. Following table shows the water quality index and their methods used during testing.

S.N.	Parameter	Method of determination
1	Temperature	Dipping of thermometer
2	Colour	Colour matching technique
3	Turbidity	Nephelometer method
4	Odour	Dilution method
5	Electrical Conductivity	Conductivity meter method
6	Suspended Solids	Filtration method
7	Oil and Grease	5520 B. Partition-Gravimetric Method
8	Alkalinity	2320 B. Titration Method
9	Total Hardness	2340 C. EDTA Titrimetric Method
10	Calcium	EDTA titration
11	pH	pH meter
12	Total Solids	Evaporation Method
13	COD	5220 B. Open reflux method
14	BOD	By DO Consumption Calculation
15	DO	4500-0 C. Azide Modification method
16	Fluorides	4500-F D. Spadns Method
17	Sulphates	4500-SO_4^{2-} E. Turbidimetri Method
18	Phosphate	4500-P D. Stannous Chloride Method
19	Chlorides	4500-Cl B. Argentometric Method
20	Nitrate	4500-NO_3^- B. Ultraviolet Spectrophotometric Screening Method

Table 2: Standard water quality parameters determination methods

III. Results and Discussion

A. Water Quality Index

1) W.Q.I. at station A

Parameter	Test Value (V_n)	Unit	Standard Permissible Limit (S_i)	Relative Weight $W_i=1/S_i$	Quality Rating $Q_i=100(V_n-V_i)/(S_i-V_i)$	Weighted Value W_iQ_i
Temperature	34.5	^{0}C	4	0.25	862.50	215.625
Colour	Yellow turbid	TCU	-	-	-	-
Turbidity	91	NTU	10	0.1	910	91
Odour	Unpleasant	TON	-	-	-	-
Conductivity	548.26	$\mu S/cm$	300	0.0033	182.70	0.619
Suspended Solids	250	mg/l	100	0.01	250	2.5
Oil and Greases	4.00	mg/l	10	0.1	40	4
Alkalinity	130	mg/l	200	0.005	65	0.325
Total Hardness	192	mg/l	300	0.0033	64	0.211
Calcium	48	mg/l	200	0.005	24	0.12
pH	6.56	unit	8.5	0.117	3.00	0.351
Total Solids	880	mg/l	500	0.002	176	0.352
COD	680	mg/l	250	0.004	272	1.088
BOD	550	mg/l	6	0.166	9166.66	1521.665
DO	0.3	mg/l	5	0.2	151.08	30.216
Chlorides	52	mg/l	250	0.004	20.8	0.0832
Fluorides	1.69	mg/l	0.3	3.33	563.33	1875.888
Sulphates	12	mg/l	200	0.005	6.00	0.03
Phosphates	2.5	mg/l	-	-	-	-
Nitrate	11.8	mg/l	45	0.022	26.22	0.262

Table 3: Calculation of Water Quality Index at station A

$\sum Wn = 4.3266 \quad \sum Wn \times Qn = 3344.33 \quad WQI = 3344.33 \div 4.3266 = 865.42$

$WQI = \sum Wn \times Qn \div \sum Wn$

2) W.Q.I. at station B

Parameter	Test Value (V_n)	Unit	Standard Permissible Limit (S_i)	Relative Weight $W_i=1/S_i$	Quality Rating $Q_i=100(V_n-V_i)/(S_i-V_i)$	Weighted Value W_iQ_i
Temperature	29	^{0}C	4	0.25	725	181.25
Colour	4.6	TCU	-	-	-	-
Turbidity	6.0	NTU	10	0.1	60.00	6.00
Odour	2.0	TON	-	-	-	-
Conductivity	368.26	$\mu S/cm$	300	0.0033	122.75	0.40
Suspended Solids	14.8	mg/l	100	0.01	14.80	0.148
Oil and Greases	0.29	mg/l	10	0.1	2.90	0.29
Alkalinity	105.06	mg/l	200	0.005	52.53	0.26
Total Hardness	57.00	mg/l	300	0.0033	19.00	0.0625
Calcium	3.63	mg/l	200	0.005	1.84	0.0092
pH	7.4	unit	8.5	0.117	26.6615	3.11
Total Solids	104	mg/l	500	0.002	20.80	0.0416
COD	10.78	mg/l	250	0.004	4.31	4.12
BOD	2.67	mg/l	6	0.166	44.50	7.38
DO	7.9	mg/l	5	0.2	68.47	13.69
Chlorides	39.04	mg/l	250	0.004	15.61	0.062
Fluorides	0.63	mg/l	0.3	3.33	210	699.30
Sulphates	26.78	mg/l	200	0.005	13.39	0.066
Phosphates	0.37	mg/l	-	-	-	-
Nitrate	3.63	mg/l	45	0.022	8.06	0.177

Table 4: Calculation of Water Quality Index at station B

$$\sum Wn = 4.3266 \quad \sum Wn \times Qn = 916.36 \qquad WQI = 916.36 \div 4.3266 = 211.80$$

$$WQI = \sum Wn \times Qn \div \sum Wn$$

3) W.Q.I. at station C

Parameter	Test Value (V_n)	Unit	Standard Permissible Limit (S_i)	Relative Weight $W_i=1/S_i$	Quality Rating $Q_i=100(V_n-V_i)/(S_i-V_i)$	Weighted Value W_iQ_i
Temperature	31.3	^{0}C	4	0.25	782.50	195.62
Colour	Light Yellow	TCU	-	-	-	-
Turbidity	26	NTU	10	0.1	260.00	26.00
Odour	Fishery Odour	TON	-	-	-	-
Conductivity	448.60	$\mu S/cm$	300	0.0033	149.53	0.49
Suspended Solids	87.93	mg/l	100	0.01	87.93	0.87
Oil and Greases	1.86	mg/l	10	0.1	18.60	1.86
Alkalinity	112.37	mg/l	200	0.005	56.18	0.28
Total Hardness	113	mg/l	300	0.0033	37.66	0.13
Calcium	31.34	mg/l	200	0.005	15.67	0.078
pH	7.08	unit	8.5	0.117	5.33	0.62
Total Solids	304	mg/l	500	0.002	60.80	0.12
COD	342	mg/l	250	0.004	136.80	0.54
BOD	268	mg/l	6	0.166	4466.66	741.46
DO	2.64	mg/l	5	0.2	1.25	0.25
Chlorides	44.83	mg/l	250	0.004	17.93	0.071
Fluorides	0.94	mg/l	0.3	3.33	313.33	1043.38
Sulphates	17.63	mg/l	200	0.005	8.815	0.044

Phosphates	.83	mg/l	-	-	-	-
Nitrate	6.8	mg/l	45	0.022	15.11	0.33

Table 5: Calculation of Water Quality Index at station C

$\sum Wn = 4.3266 \quad \sum Wn \times Qn = 2012.143 \qquad WQI = 2012.143 \div 4.3266 = 465.06$

$WQI = \sum Wn \times Qn \div \sum Wn$

4) W.Q.I. at station D

Parameter	Test Value (V_n)	Unit	Standard Permissible Limit (S_i)	Relative Weight $W_i=1/S_i$	Quality Rating $Q_i=100(V_n-V_i)/(S_i-V_i)$	Weighted Value W_iQ_i
Temperature	21	^{0}C	4	0.25	525	131.25
Colour	3.92	TCU	-	-	-	-
Turbidity	4.2	NTU	10	0.1	42	4.2
Odour		TON	-	-	-	-
Conductivity	390	$\mu S/cm$	300	0.0033	130	0.43
Suspended Solids	104.40	mg/l	100	0.01	104.40	1.04
Oil and Greases	0.15	mg/l	10	0.1	1.50	0.15
Alkalinity	183.64	mg/l	200	0.005	91.82	0.058
Total Hardness	168.65	mg/l	300	0.0033	56.21	0.185
Calcium Hardness	23.45	mg/l	200	0.005	11.72	0.0586
pH	7.8	unit	8.5	0.117	53.33	6.23
Total Solids	253.60	mg/l	500	0.002	50.72	0.101
COD	26.65	mg/l	250	0.004	10.66	0.0426
BOD	16.67	mg/l	6	0.166	277.83	4.61
DO	5.68	mg/l	5	0.2	92.60	18.52
Chlorides	8.4	mg/l	250	0.004	3.36	0.013
Fluorides	0.54	mg/l	0.3	3.33	180	599.40
Sulphates	21.04	mg/l	200	0.005	10.52	0.052
Phosphates	0.29	mg/l	-	-	-	-
Nitrate	7.7	mg/l	45	0.022	16.94	0.372

Table 6: Calculation of Water Quality Index at station D

$\sum Wn = 4.3266 \quad \sum Wn \times Qn = 766.72 \qquad WQI = 766.72 \div 4.3266 = 177.20$

$WQI = \sum Wn \times Qn \div \sum Wn$

5) W.Q.I. at station E

Parameter	Test Value (V_n)	Unit	Standard Permissible Limit (S_i)	Relative Weight $W_i=1/S_i$	Quality Rating $Q_i=100(V_n-V_i)/(S_i-V_i)$	Weighted Value W_iQ_i
Temperature	20.10	^{0}C	4	0.25	502.50	125.63
Colour	4.23	TCU	-	-	-	-
Turbidity	3.93	NTU	10	0.1	39.30	3.93
Odour		TON	-	-	-	-
Conductivity	492	$\mu S/cm$	300	0.0033	164	0.541
Suspended Solids	94.60	mg/l	100	0.01	94.60	0.946
Oil and Greases	0.19	mg/l	10	0.1	1.90	0.19
Alkalinity	117.8	mg/l	200	0.005	58.90	
Total Hardness	186	mg/l	300	0.0033	62	0.2046
Calcium Hardness	25.52	mg/l	200	0.005	12.76	0.064
pH	8.04	unit	8.5	0.117	226.08	26.45
Total Solids	283.78	mg/l	500	0.002	56.75	0.113
COD	21.36	mg/l	250	0.004	8.54	0.034
BOD	11.42	mg/l	6	0.166	190.33	31.59
DO	6.80	mg/l	5	0.2	80.43	16.086

Chlorides	11.2	mg/l	250	0.004	4.48	0.0179
Fluorides	0.43	mg/l	0.3	3.33	143.33	477.28
Sulphates	19.30	mg/l	200	0.005	9.65	0.048
Phosphates	0.33	mg/l	-	-	-	-
Nitrate	8.9	mg/l	45	0.022	19.77	0.435

Table 7: Calculation of Water Quality Index at station E

$\sum Wn = 4.3266 \quad \sum Wn \times Qn = 683.56 \qquad WQI = 683.56 \div 4.3266 = 157.98$

$WQI = \sum Wn \times Qn \div \sum Wn$

6) W.Q.I. at station F

Parameter	Test Value (V_n)	Unit	Standard Permissible Limit (S_i)	Relative Weight $W_i=1/S_i$	Quality Rating $Q_i=100(V_n-V_i)/(S_i-V_i)$	Weighted Value W_iQ_i
Temperature	35.9	^{0}C	4	0.25	897.50	224.37
Colour	Yellow turbid	TCU	-	-	-	-
Turbidity	8.7	NTU	10	0.1	87	8.7
Odour	Unpleasant	TON	-	-	-	-
Conductivity	586.32	$\mu S/cm$	300	0.0033	195.44	0.644
Suspended Solids	232	mg/l	100	0.01	232	2.32
Oil and Grease	5.0	mg/l	10	0.1	50	5
Alkalinity	152.4	mg/l	200	0.005	76.20	0.381
Total Hardness	218	mg/l	300	0.0033	72.66	0.239
Calcium	53.06	mg/l	200	0.005	26.53	0.1326
pH	6.82	unit	8.5	0.117	16	0.187
Total Solids	528	mg/l	500	0.002	105.60	0.211
COD	613.46	mg/l	250	0.004	245.38	0.981
BOD	558	mg/l	6	0.166	9300	1543.80
DO	0.47	mg/l	5	0.2	149.23	29.84
Chlorides	67.8	mg/l	250	0.004	27.12	0.108
Fluorides	1.63	mg/l	0.3	3.33	543.33	1809.28
Sulphates	14.68	mg/l	200	0.005	7.34	0.037
Phosphates	2.37	mg/l	-	-	-	-
Nitrate	10.8	mg/l	45	0.022	24	0.533

Table 8: Calculation of Water Quality Index at station F

$\sum Wn = 4.3266 \quad \sum Wn \times Qn = 3626.48 \qquad WQI = 3626.48 \div 4.3266 = 838.183$

$WQI = \sum Wn \times Qn \div \sum Wn$

7) W.Q.I. at station G

Parameter	Test Value (V_n)	Unit	Standard Permissible Limit (S_i)	Relative Weight $W_i=1/S_i$	Quality Rating $Q_i=100(V_n-V_i)/(S_i-V_i)$	Weighted Value W_iQ_i
Temperature	22.01	^{0}C	4	0.25	550.25	137.50
Colour	2.96	TCU	-	-	-	-
Turbidity	4.04	NTU	10	0.1	40.40	4.040
Odour	-	TON	-	-	-	-
Conductivity	430	$\mu S/cm$	300	0.0033	143.33	0.473
Suspended Solids	117.18	mg/l	100	0.01	117.18	1.17
Oil and Grease	0.21	mg/l	10	0.1	2.10	0.21
Alkalinity	123.68	mg/l	200	0.005	61.84	0.309
Total Hardness	158.58	mg/l	300	0.0033	52.86	0.174
Calcium Hardness	26.39	mg/l	200	0.005	13.19	0.0659
pH	7.83	unit	8.5	0.117	55.33	6.473
Total Solids	274.46	mg/l	500	0.002	54.89	0.109

COD	31.68	mg/l	250	0.004	12.67	0.0506
BOD	18.31	mg/l	6	0.166	305.17	50.658
DO	6.32	mg/l	5	0.2	85.65	17.13
Chlorides	8.01	mg/l	250	0.004	3.204	0.0128
Fluorides	0.59	mg/l	0.3	3.33	196.67	654.911
Sulphates	23.06	mg/l	200	0.005	11.53	0.0576
Phosphates	0.21	mg/l	-	-	-	-
Nitrate	6.9	mg/l	45	0.022	15.33	0.340

Table 9: Calculation of Water Quality Index at station G

$\sum Wn = 4.3266 \quad \sum Wn \times Qn = 873.68 \qquad WQI = 873.68 \div 4.3266 = 201.933$

$WQI = \sum Wn \times Qn \div \sum Wn$

8) W.Q.I. at station H

Parameter	Test Value (V_n)	Unit	Standard Permissible Limit (S_i)	Relative Weight $W_i=1/S_i$	Quality Rating $Q_i=100(V_n-V_i)/(S_i-V_i)$	Weighted Value W_iQ_i
Temperature	20.68	^{0}C	4	0.25	517	129.25
Colour	Clear Water	TCU	-	-	-	-
Turbidity	2.87	NTU	10	0.1	28.70	2.870
Odour	-	TON	-	-	-	-
Conductivity	398.26	µS /cm	300	0.0033	132.75	0.438
Suspended Solids	103.32	mg/l	100	0.01	103.32	1.033
Oil and Greases	0.20	mg/l	10	0.10	2.0	0.20
Alkalinity	107.23	mg/l	200	0.005	53.62	0.2681
Total Hardness	178.36	mg/l	300	0.0033	59.45	0.196
Calcium	29.83	mg/l	200	0.005	14.92	0.074
pH	7.94	unit	8.5	0.117	62.67	7.332
Total Solids	298.53	mg/l	500	0.002	59.70	0.119
COD	24.19	mg/l	250	0.004	9.67	0.0386
BOD	11.27	mg/l	6	0.166	187.83	31.179
DO	6.83	mg/l	5	0.2	80.11	16.022
Chlorides	9.20	mg/l	250	0.004	3.68	0.014
Fluorides	0.47	mg/l	0.3	3.33	156.67	521.71
Sulphates	20.80	mg/l	200	0.005	10.40	0.052
Phosphates	0.17	mg/l	-	-	-	-
Nitrate	7.50	mg/l			16.67	0.370

Table 10: Calculation of Water Quality Index at station H

$\sum Wn = 4.3266 \quad \sum Wn \times Qn = 711.16$

$WQI = \sum Wn \times Qn \div \sum Wn$

$WQI = 711.16 \div 4.3266 = 164.37$

IV. CONCLUSION

Water quality index of the river was found satisfactory before inclusion of waste water from sugar industry but after mixing of the waste water the quality of water decreases the course of river and it were not suitable for drinking and irrigation purpose. Most of the water quality index have higher values than the standard values given by Bureau Indian Standard as well as World Health Organization guidelines. Some positive steps should be taken by local authority to improve the water quality of river. Local public should be aware about the water pollution and adopt preventive measures for controlling the river and ground water pollution.

REFERENCES

[1] Boyacioglu, H. (2006). Surface water quality assessment using factor analysis. Water SA. 32(3), 383-393.
[2] Burn, D.H. and McBean, E.A. (1985). Optimization modeling of water quality in an uncertain environment. Water Resource. 2 (2), 42- 44.
[3] Catell, R.B. and Jaspers, J. (1967). A general Plasmode (No. 30-10-5-2) for actor analytic exercises and research. Mult. Behav. Res. Monogr. 67, 1-212.
[4] David, A. (1963). Report on fisheries survey of river Gandak (North Bihar). Sur. Rep. Cent. Inl. Fish Res. Inst. Barrackpore, 1: 24.
[5] Ray, P., S. B. Singh and K. I. Sehgal (1966). A study of some aspect of ecology of river Ganga and Yamuna at Allahbad, U. P. in 1958-59. Proc. Nat. Acad. Sci. India,36(3): 235.

[6] Pahwa, D. V. and S. M. Mehrotra (1966). Observations of fluctuations in the abundance of planton in relation to certain Hydro-biological conditions of river Ganga. Proc .Nat. Acd. Sc. Ind., 36 (2): 157-189.
[7] Vyas, L. N. (1968). Studies on phytoplankton ecology of Pichhola Lake,Udaipur. Proc. Symp. Recent Adv. Trop. Ecol., Int. Soc. Trop. Ecol., Varanasi (ed. R. Mishra and B. Gopal): 334-347.
[8] David, A., P. Ray, B.V. Govind, K.V. Rajgopal and R.K. Banerjee (1969). Limnology and fisheries of Tungbhadra reservoir, Bull Cent. Inl. Fish Res. Inst. Barrackpore, 13:188.
[9] Choubey, O.N. and YadavRanjana, 2009.Environmental assessment of Kareli Sugar Mill effluent on local groundwater.Journal of Indust.Poll.Cont. 25.
[10] Manivasakam, N. 2002.Physico Chemical Examination of Water Sewage and Industrial Effluents.PragatiPrakashan p. 234.
[11] Panda, S.C., Kar, R.N., Patra, P. and Das, B. 2000.Environmental study of a sugar factory.Eco.Env.Conserv. 6(1): 13-18.
[12] Senthil Kumar, R.D., Narayana Swami, R. and Ramakrishan, K. 2001. Pollution studies on sugar mill effluent physic-chemical characteristics and toxic metals. Polln. Res. 20 (1): 93-97.
[13] Trivedy, R.K. and Goel, P.K. 1986. Chemical and Biological Methods for Water Pollution Studies. Environmental publication, Karad, India pp 2-31.
[14] Wahane, J.K., Banerjee Juhi, Udaipure, S.K. and Choubey, O.N. 2010.Environmental assessment of effluent of soya solvent extraction plant of Pipariadisti.Hoshangabad. Int. J.Chem. Sci. 8 (1): 623-627.
[15] Wahane, J.K. and Diwakar, S.K. 2012.Environmental assessment of local ground water by effluent of soya solvent extraction plant of Chhindwara (Partala). Frontiers in Environmental Research (ISBN) New Delhi 1st edition 253-257.
[16] World Health Organization (WHO) 1975. International Standard of Drinking Water Geneva.

