PHYSICO-CHEMICAL ANALYSIS AND POLLUTION LEVEL OF ONE OF THE DISTILLERY EFFLUENTS IN – UNNAO, INDIA

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Keywords: characterization of distillery effluents, chemical and biological oxygen demand (BOD, COD), total dissolved solids (TDS) content, wastewater analysis, pollution level, correlation of wastewater parameters

A detailed analysis was undertaken to determine the physico-chemical characteristics and pollution level in the sample collected from one of the distillery situated in the area of Unnao, India. The samples were collected from a fixed spot of the distillery in one year duration from Jan 2011 to Dec. 2011 at monthly interval. Presence of high chemical load like iron, calcium, magnesium, carbonate, bicarbonate, chloride, BOD, COD etc. were observed in the discharged effluent of the above stated distillery. High variations were observed according to monthly level and results showed that there are certain relationships between physico- chemical characteristics of effluents of both positive and negative.

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Introduction

Water has always played a prominent role in human civilization. When people first began settling in one place and growing crops for sustenance, it was invariably near water sources like rivers, lakes, or groundwater springs. Water was needed for drinking, preparing food, bathing, cleaning, irrigating crops, and a variety of other tasks, so it was important to have ready access to this resource. The water sources used for supplying water were not always clean however, and treating drinking water to improve smell, taste, clarity, or to remove disease-causing pathogens has occurred in one form or another throughout recorded history. The quality of water is of vital concern for mankind since it is directly linked with human welfare. Generally speaking, water pollution is a state of deviation from the pure condition, whereby its normal function and properties are affected. Water quality, characteristics of aquatic environments arise from a multitude of physical, chemical and biological interactions. The water bodies, rivers, lake and estuaries are continuously subject to a dynamic state of change with respect to their geological age and geochemical characteristics. This dynamic balance in the aquatic eco-system is upset by human activities, resulting in pollution which is manifested dramatically as fish kill, offensive taste and odor. Effluents generated by industries are sources for a type of pollution known as industrial pollution.

Distillery effluent is the resulting liquid flow from the waste water treatment system of the distilleries. Distilleries are one of the 17 most polluting industries listed by the Central Pollution Control Board. At present, there are 319 distilleries in India with an installed capacity of 3.29 billion liter of alcohol. The cane-growing states like Uttar Pradesh and Maharashtra have the highest installed capacity constituting more than 40% of the total installed capacity, followed by Madhya Pradesh (14.2%) and Tamil Nadu (9.7%). For every liter of alcohol produced, molasses based distilleries generate 8-15 L of waste water characterized by high BOD and high COD.[1] The total waste water produced per liter of alcohol production is around 40 to 50 liters.[2] About 40.72 million m^3 spent wash is generated annually from distilleries in India.[3]

Materials and Experimental Methods

Samples and sampling sites

Samples were taken from one of the tannery from Unnao city of India. The samples of effluent were collected from distillery for one month intervals from the spots fixed. The samples were collected in glass bottle (1.0 litre) and were corked immediately. All the samples were brought to the laboratory and stored at 4 ^{0}C temperatures in refrigerator till the analyses were completed. All chemical analyses were done in evening or the following days. All four or five samples of different sites were combined to get an integrated sample of the water. This sample was used for the tests given below. The sampling procedure was same as described in Indian standard methods of sampling and test for water used in industries, I.S.I. New Delhi, India.

The physical and chemical characteristics analyzed for the effluents were color, temperature, pH, carbonate, bicarbonate, chloride, total alkalinity, nitrite, total hardness, alkaline hardness, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), oxygen consumed by potassium permanganate, BOD, calcium, potassium, magnesium, phosphorus, sulfur, nitrogen, iron and manganese. The pH and temperature measurements were performed for each of the above given components were same as described in IBH hand book No.-8,[4] USDA hand book no.-60[5] and Laboratory methods for blue green algae,[6] Standard methods for sampling and test for water used in industries, ISI New Delhi is 2490[7] and as earlier used by Mohan.[8] The correlation-ships between various characteristics of effluent tested were worked out. The concentration of dissolved oxygen (DO) present in

effluent samples was estimated by Winkler method. The alkalinity was analyzed by titrating against sodium thiosulfate using as indicator.[9] The BOD, TDS, and TS determination of effluent samples were carried out using standard methods.[10] The determination of COD was carried out according to Ademoroti.[11]

All data were statistically analyzed and tested for significance at 5% and 10% probability levels. For significant and highly significant '*r*' values respectively one and two asterisks have been used.

Results and Discussion

Result of the analysis of distillery effluents are showed in Table 1 and their correlation coefficients are given in Table 2 this result shows that the effluents are yellowish color between the month of November and February while brown color between the month of April and October with offensive odor. Temperatures of the effluents are ranges from 20 ºC to 32 ºC. pH value of effluent was in slight acidic range. Amount of dissolved oxygen in effluents are nil in the month between April and September while very small amount of dissolved oxygen (DO) were found in the month between October and March i.e. 0.7 to 2.6 meq.L^{-1}while the recommended BIS range is 4-6. The absence or very small amount of dissolved oxygen is probably due to high organic load.[12] BOD and COD of this analysis is very high in the month of July i.e. 4400 and 6470 meq.L^{-1} respectively while least value 3550 and 5220 meq.$L^{-1}$of BOD and COD respectively was found in the month of October. The highest value of total solid (TS) was 2038 meq.L^{-1} in the month of July while the least value 714 meq.L^{-1} of TS was in the month of February these values of total solids in distillery effluents was much high from the BIS recommended range i.e. 100.[12] Total alkalinity as $CaCO_3$ was found highest value 1345 meq.L^{-1} in the month of July where as least value 950 meq.L^{-1} almost similar results were also obtained by Nagendra Kumar Chaurasia et al.[13] Calcium, potassium, magnesium, phosphorous, sulfur, nitrogen, iron and manganese were also analyses and their results are given in table no. 1 values of these elements were found very much high than the recommended values.

Positive correlationship

Positive correlation coefficients were found between temperature with each carbonate bicarbonate, chloride, nitrite, alkaline hardness, TS, TDS, magnesium, nitrogen and iron. pH with each TS, DO, oxygen consumed by $KMnO_4$, calcium, potassium, magnesium, sulfur, nitrogen and iron; carbonate with each bicarbonate, chloride, total alkalinity, nitrite, total hardness and alkaline hardness, TS, TDS, TSS, BOD, COD, phosphorous, sulfur and manganese; bicarbonate with each chloride, total alkalinity, nitrite, TS, TDS, TSS, BOD, COD, calcium, phosphorous, sulfur and manganese; chloride with each nitrite, total hardness, alkaline hardness, TS, TDS, TSS, calcium sulfur and manganese. total alkalinity with each nitrogen, alkaline hardness, TS, TDS, TSS, BOD, COD, calcium, potassium, magnesium, sulfur and manganese; nitrite with each of the total hardness, TS, TDS, TSS, DO, BOD, COD and nitrogen. total hardness with each of the alkaline hardness, TS, TDS, TSS, BOD, COD, calcium, magnesium, phosphorous, sulfur and manganese; alkaline hardness with each of the TS, TDS, TSS, BOD, COD, calcium, magnesium, phosphorous, sulfur and manganese; TS with each of the TDS, TSS, DO, BOD, COD, phosphorous and sulfur; TDS with each TSS, BOD, COD, magnesium, phosphorous, sulfur and nitrogen; TSS with each of the BOD, COD, magnesium, phosphorous, nitrogen and manganese. DO with each of the calcium, potassium, magnesium, nitrogen, iron and manganese. BOD with each of the COD, oxygen consumed by $KMnO_4$, potassium, magnesium, phosphorous, sulfur, nitrogen, iron and manganese. COD with each of the oxygen consumed by $KMnO_4$, calcium, potassium, magnesium, phosphorous, sulfur, nitrogen, iron and manganese; oxygen consumed by $KMnO_4$ with each of the calcium, potassium, magnesium, sulfur and nitrogen; calcium with each of the potassium, magnesium, phosphorous, sulfur, nitrogen, iron and manganese; potassium with each of the sulfur, nitrogen, iron and manganese; magnesium with each of the phosphorous, sulfur, nitrogen, iron and manganese; phosphorous with each of the sulfur, nitrogen, iron and manganese; sulfur and nitrogen with manganese.

Negative correlationship

Negative correlation coefficient were found between temperature with each of the pH, total alkalinity, total hardness, TSS, DO, BOD, COD, oxygen consumed by $KMnO_4$, calcium, phosphorous, sulfur and manganese. pH with each of the carbonate, bicarbonate, chloride, total alkalinity, nitrite, total hardness, alkaline hardness, TDS, TSS, BOD, COD and manganese; carbonate with each of the DO, oxygen consumed by $KMnO_4$, calcium, potassium, magnesium, nitrogen and iron. bicarbonate with each of the total hardness, alkaline hardness, DO, oxygen consumed by $KMnO_4$, potassium, magnesium, nitrogen and iron. Chloride with each of the total alkalinity, DO, BOD, COD, oxygen consumed by $KMnO_4$, potassium, magnesium, phosphorous, nitrogen and iron; total alkalinity with each of the total hardness, DO, oxygen consumed by $KMnO_4$, nitrogen and iron. nitrite with each of the alkaline hardness, oxygen consumed by $KMnO_4$, calcium, potassium, magnesium, phosphorous, sulfur, iron and manganese; total hardness with each of the DO, oxygen consumed by $KMnO_4$, potassium, nitrogen and iron; alkaline hardness with each of the DO, oxygen consumed by $KMnO_4$, calcium, potassium, nitrogen and iron; TS with each of the oxygen consumed by $KMnO_4$, calcium, potassium, magnesium, nitrogen, iron and manganese; TDS with each of the DO, oxygen consumed by $KMnO_4$, calcium, potassium, magnesium, nitrogen, iron and manganese; TSS with each of the DO, oxygen consumed by $KMnO_4$, calcium, potassium, sulfur and nitrogen; DO with each of the BOD, COD, oxygen consumed by $KMnO_4$, phosphorous and sulfur; BOD with calcium. oxygen consumed by $KMnO_4$, with each of the phosphorous, iron and manganese; potassium with magnesium and phosphorous. Sulfur with each of the nitrogen and iron; nitrogen with each of the iron and manganese.

These high value of chemical and physical properties of effluents shows that the discharging of effluents in river is very harm full to aquatic as well as human life while loss of soil fertility of agricultural area causes most probably due to effluents discharging in these areas.

Table 1. Analysis of distillery effluents

Period of sample	CHARACTERISTICS OF EFFLUENT																								
	Color	Temp. (°C)	pH	Carbonate	Bicarbonate	Chloride	Total Alkalinity as $CaCO_3$	Total Cr	Total Hardness as $CaCO_3$	Alkaline Hardness as $CaCO_3$	TS	TDS	TSS	DO	BOD	COD	Oxygen Consumed by $KMnO_4$ in 3 hrs	Ca	K	Mg	P	S	N	Fe	Mn
				meq. L^{-1}														mg L^{-1} effluent							
Jan. 2011	Light Yellow	23.7	7.4	1.5	1.0	67	1220	Nil	945	235	1045	1235	787	1.5	4350	6397	1.5	237	142	23.4	112	223	1165	4.20	0.76
Feb. 2011	Yellow	24.0	7.2	0.8	0.5	89	1323	Nil	832	287	714	1176	727	2.3	3700	5441	1.3	366	165	33.8	118	187	1155	4.86	0.63
Mar. 2011	Brown	24.5	6.8	6.5	0.3	45	1324	Nil	934	356	1035	1406	757	2.6	3900	5735	2.7	185	65	31.0	259	263	1055	4.60	0.69
Apr. 2011	Light Brown	28.5	5.1	4.9	3.9	530	1330	Nil	2285	875	1997	1440	897	Nil	4300	6323	2.0	244	97	33.8	239	279	1080	3.57	1.72
May. 2011	Brown	30.6	4.9	4.6	3.7	511	1255	Nil	1255	831	1935	1385	940	Nil	4150	6102	1.5	160	127	6.8	162	72	1150	4.30	0.90
Jun. 2011	Brown	32.0	5.8	5.2	4.2	524	1343	Nil	1705	850	1832	1375	862	Nil	3600	5294	1.6	348	65	36.4	162	660	1160	2.65	1.76
Jul. 2011	Brown	29.5	6.4	4.8	2.9	539	1345	0.05	2115	810	2038	1308	975	Nil	4400	6470	1.4	94	77	7.0	32	64	1160	2.70	0.73
Aug. 2011	Brown	29.4	5.5	5.1	3.1	480	1219	0.03	1462	868	1825	1565	832	Nil	3800	5588	1.0	88	57	32.2	154	175	1050	4.40	1.30
Sept. 2011	Brown	28.0	5.0	5.8	1.9	545	1239	Nil	2366	834	1897	1277	904	Nil	3600	5294	1.6	180	75	24.2	142	175	1020	4.30	0.76
Oct. 2011	Brown	28.0	6.0	4.9	2.8	Nil	1070	Nil	1240	690	1445	1010	780	0.7	3550	5220	1.3	225	76	23.0	106	175	1100	4.25	0.86
Nov. 2011	Yellowish	22.8	6.8	1.8	0.9	Nil	950	Nil	670	340	742	855	683	1.6	3950	5808	1.4	185	72	26.5	117	174	1050	4.60	1.34
Dec. 2011	Yellowish	20.7	7.1	1.6	0.7	Nil	1100	Nil	795	370	815	930	640	1.4	4300	6323	1.6	235	121	23.8	130	225	1340	3.76	0.65

Table 2. Correlation coefficients

Variables	pH	CO_3^{2-}	HCO_3	Cl	Total Alkalinity	NO_2	Total Hardness	Alkaline Hardness	TS	TDS	TSS	DO	BOD	COD	O_2 consumed by $KMnO_4$	Ca	K	Mg	P	S	N	Fe	Mn
Temp.	-0.78	-0.69	-0.909**	-0.024	-0.246	-0.846**	-0.175	-0.123	-0.043	-0.043	-0.032	-0.123	-0.145	-0.146	-0.178	-0.289	-0.402*	-0.282	-0.181	-0.133	+0.327*	-0.445*	-0.461**
pH		-0.68	-0.683**	-0.567*	-0.317*	-0.532*	-0.767**	-0.967**	-0.798**	-0.487*	-0.876**	-0.878**	-0.028	-0.047	-0.943**	-0.267	-0.296	-0.260	-0.323*	-0.022	+0.228	-0.327*	-0.186
CO_3^{2-}			-0.892**	-0.867**	-0.165	-0.432*	-0.778**	-0.967**	-0.834**	-0.378**	+0.812**	-0.968**	-0.034	+0.065	-0.967**	-0.365	-0.023	-0.181	-0.056	-0.052	-0.136	-0.446*	-0.116
HCO_3				-0.673*	-0.343*	-0.398**	-0.867**	-0.948**	-0.823**	-0.589**	+0.887**	-0.976**	-0.221	+0.324	-0.935**	-0.345*	-0.424	-0.208	-0.161	-0.081	-0.373*	-0.484*	-0.134
Cl					-0.012	-0.853**	-0.567	-0.767*	-0.623**	-0.176	+0.576*	-0.812**	-0.056	-0.087	-0.212	-0.312	-0.345*	-0.226	-0.019	-0.021	-0.159	-0.449*	-0.168
Total Alkalinity						-0.567*	-0.543*	-0.286	-0.405	-0.767**	+0.534*	-0.045	-0.234	+0.432	-0.066	-0.234	-0.065	-0.291	-0.318	-0.288*	-0.199	-0.319	-0.036
NO_2							-0.518*	-0.605**	-0.956	-0.606**	+0.387	-0.535*	-0.765**	+0.567*	-0.954**	-0.648*	-0.556*	-0.890**	-0.514**	-0.105	+0.129	-0.917*	-0.571**
Total Hardness								-0.812**	+0.865**	-0.545*	+0.823**	-0.656*	-0.065	+0.076	-0.734*	-0.187	-0.178	-0.099	-0.133	-0.153	-0.201	-0.528*	-0.299
Alkaline Hardness									-0.313	-0.465*	+0.856**	-0.956**	-0.223	+0.543*	-0.918**	-0.367*	-0.474*	-0.313*	-0.160	-0.061	-0.323*	-0.455*	-0.122
TS										-0.602**	+0.834*	-0.854**	-0.109	+0.334	-0.936**	-0.343	-0.158	-0.250	-0.142	-0.024	-0.140	-0.388*	-0.034
TDS											+0.656*	-0.478*	-0.212	+0.432	-0.323	-0.246	-0.288	-0.083	-0.449*	-0.159	+0.129	-0.176	-0.176
TSS												-0.867**	-0.123	+0.243	-0.768*	-0.354	-0.311	-0.345*	-0.123	-0.083	+0.039	-0.501*	-0.118
DO													-0.034	-0.056	-0.967**	-0.367*	-0.303	-0.234	-0.084	-0.126	+0.218	-0.496*	-0.035
BOD														+0.523*	-0.122	-0.073	-0.058	-0.041	-0.102	-0.019	+0.051	-0.252	-0.116
COD															-0.467	-0.087	-0.064	-0.134	-0.456*	-0.076	+0.064	-0.324	-0.167
O_2 consumed by $KMnO_4$																-0.312	-0.19	-0.18	-0.012	-0.022	+0.394*	-0.398	-0.187
Ca																	-0.582**	-0.578**	-0.196	-0.641**	+0.261	-0.015	-0.424*
K																		-0.124	-0.051	-0.174	+0.245	-0.173	-0.116
Mg																			-0.504*	-0.769**	+0.285	-0.348*	-0.376*
P																				-0.497*	+0.209	-0.286	-0.509*
S																					-0.061	-0.280	-0.423*
N																						-0.035	-0.087
Fe																							-0.089
Mn																							

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

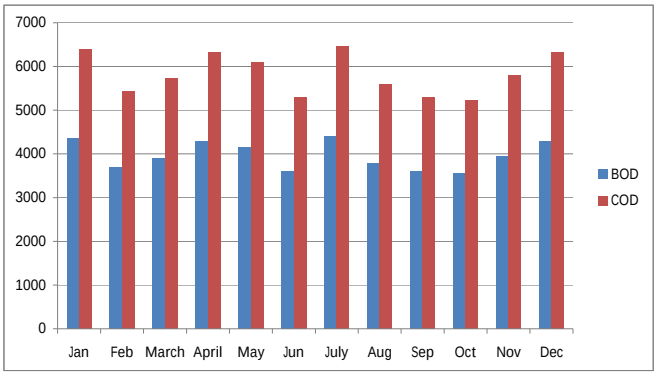

Figure 1. A comparative chart between important physical parameters like BOD and COD

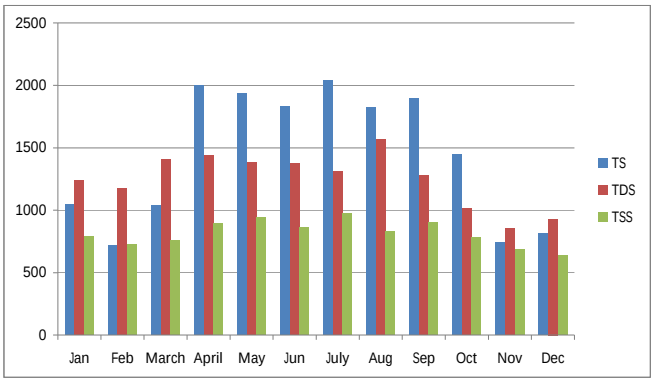

Figure 2. A comparative chart between physical parameters TS, TDS and TSS X- Axis Time interval; Y-Axis Amount in meq. L^{-1}

Conclusion

The assessment of the distillery effluent is carried out and observed that the distillery effluent was brown, turbid and had an offensive odour. The pH of the effluent was found to be in nearly acidic range. The physical parameters in the effluent indicates namely total hardness, total suspended and dissolved solids were at higher level. The chemical parameters namely COD, BOD, carbonate, bicarbonate, calcium, magnesium, chloride, potassium, nitrite, sulfur, and chromium, is found to be higher than the permissible limits prescribed by the Bureau of Indian Standards (2009). Distillery pollution readily accelerates to cause deterioration in ground water quality. Degradation of water quality resists its use for our daily life and also for aquatic life. This study will great helpful for developing new techniques for the treatment of effluent.

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