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PROCESS DETAILS AND EFFLUENT CHARACTERISTICS OF A RICE MILL IN THE SAMBALPUR DISTRICT OF ORISSA

ABANTI PRADHAN AND SANJAT K. SAHU

Department of Environmental Sciences, Sambalpur University
Jyoti Vihar- 768 019, Orissa, India

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ABSTRACT

A work was undertaken to study the process details and effluent characteristics of a rice mill in the district of Sambalpur, Orissa. The milling capacity of rice mill was 10 MT/day. The rice mill generates effluent in an average 100 kl/day from the paddy soaking, parboiling and boiler blow down operations. The physico-chemical characteristics of the effluent revealed an alkaline pH (8.0), with low concentration of DO (0.9 mg/L), nitrate (0.5 mg/L), phosphate (21 mg/L) and sulphate (40 mg/L); and moderate concentration of COD (630 mg/L), chloride (140 mg/L) and TDS (670 mg/L). The total suspended solids (530mg/L) and BOD (450 mg/L) were much higher than the recommended standard set by ISI (1974) for the discharge of industrial effluent into inland surface waters as well as on land for irrigation indicating the presence of high amount of organic matter in the effluent. Moreover the effluent was rich in sodium (235 mg/L), total phenols (35 mg/L) as well as silica (58 mg/L). The treatment of the rice mill effluent is highly essential to render the effluent suitable for discharge into surface water or on land for irrigation.

INTRODUCTION

Rice is one of the most important crops of the world. More than half of the world's population is supported by rice. About 95% of rice is produced and consumed in the orient- in countries like India, Bangladesh, China, Japan, Korea, Philippines, Malaysia, Indonesia, Thailand, Sri Lanka etc. Other rice producing countries are Brazil, USA, Egypt, West Africa, Spain and Italy (Grist, 1953; ICAR, 1987). In India rice is cultivated in about 22% of the gross cropped area (Jaiswal and Wadhwani, 1984). It covers about 47% and 61% of the gross cropped area in Orissa state and Sambalpur district, respectively. The area under rice in Orissa was 44.02 lakh hectares in 1985-86 which has increased to 45.48 lakh hectares in 1991-92 registering an increase of 3.32%. The production of rice in 1985-86 was 52.26 lakh MT, which icreased to 66.60 lakh MT in 1991-92 registering an increase of 27.44%. During the same period the area under cultivation and production of rice in Sambalpur district have increased by 2.52% and 29.14%, respectively.

As a result of huge production and demand for rice, number of rice mills has gone up in Orissa in last few years. In 1984-85 there were about 200 rice mills in Orissa (Behera *et. al.*, 1990). But today more than 600 rice mills are operating in Orissa out of which around 70 rice mills are located in Sambalpur district. Their milling capacity varies from 10 MT/ day to 50 MT/ day (DSHB, 1999-2000; ES, 1999-2000). Much information is, however, not available on the effluent of rice mill industry. Keeping this in view, a work was undertaken in the Sambalpur district of Orissa to study the process details of the rice mill as well as the physico-chemical characteristics of its effluent.

Process details of the rice mill

The raw paddy harvested from the field is first cleaned by paddy cleaner (chalna) to separate the impurities. The paddy is then either soaked in water for 6-8 hours or diverted directly to the boiling tank and steam from the boiler is inserted into the tank for 25-30 minutes. In the boiling tank area and common salt are added as additives to bring the glaze of rice and to suppress the boiling point respectively. The boiler uses husk as fuel, and water from the overhead tank to generate steam. After the first boiling of raw paddy, water is released into the boiling tank from the overhead tank. The paddy is kept in water for 8 hours, then water is drained and steam is again passed for 25-30 minutes . After second boiling, the paddy is taken to the drier or to the drying yard. In the drying yard the paddy is kept for 8 to 10 hours to dry under sunlight. The mechanical drier when used, uses husk as its fuel. The paddy is thereafter taken to the mill hall for milling. In the mill hall the paddy is first cleaned and then put into the rubber roll sheller for milling. After milling it is passed through a husk aspirator to separate husk. The unpolished rice is then passed to metal polisher. Here bran is separated and the polished rice passes to the rice grader. In the rice grader, broken rice is separated from intact rice and the later is then packed in bags for transportation and marketing.

In an average 68 kg rice and 2 kg broken rice are produced during ,milling of 100 kg raw paddy, besides 25 kg husk and 5 kg bran as byproducts. The bran is very often used by the oil mills for oil extraction and husk is used as fuel during boiling and drying operation of the rice mill. Water is also required as a pre-requisite during soaking and boiling operations. In an average 100 liters of water is required for processing of 100 kg raw paddy.

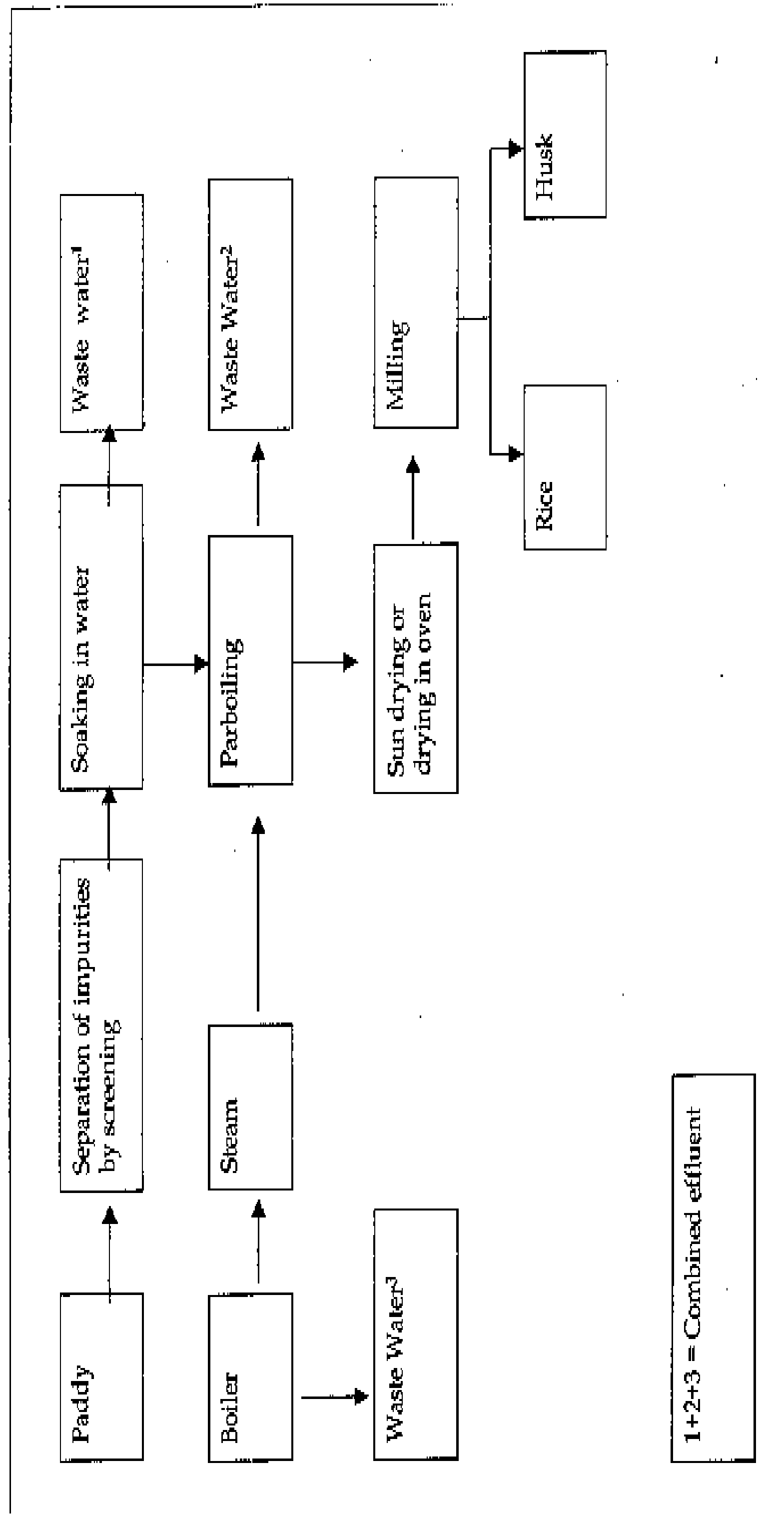

Fig. 1 Flow Sheet of Rice Mill with Sources of Waste Water.

Genesis of waste

Rice mill generates wastes mainly in the solid, liquid and gaseous forms. Husk and ash constitute the main bulk of solid wastes. However husk is reused in the mill for boiling water. So residues left after combustion is ash. Gaseous emission is mainly CO, SO_2 and NO_x. Besides these, rice mill generate liquid wastes from the following operations: parboiling wastewater, paddy soaked wastewater and boiler blow down. The liquid wastes from these operations ultimately passes through a common drain to the outside of the mill boundaries and this is commonly called as combined effluent or combined wastewater or loosely as effluent or waste water. A flow sheet of the operation of rice mill with sources of wastewater has been given in Figure -1.

Sampling and analysis of the wastewater

The wastewater was collected from the drain of a nearby rice mill located 5 km away from Sambalpur University Campus and having milling capacity 10 MT/ day. The samples were collected at bimonthly intervals during the 1st week February, April, June, August, October and December 1997. Polythylene bottles each of 2 liter capacity were used for the collection of samples. In each sampling occasion, wastewater samples were collected in triplicate between 8 and 9 AM in the morning. pH was recorded on the spot and dissolved oxygen was also fixed on the spot. The samples were then transferred to the laboratory for analysis of various physico-chemical parameters. The standard methods recommended by APHA (1989) were adopted for the analysis of wastewater.

RESULTS

The physico-chemical characteristics of the effluent of rice mill has been given in Table- 1.

Colour - The appearance of rice mill effluent was found to be brown and turbid. The turbidity is due to the shape, size and refractive index of the particulate impurities like finely divided organic and inorganic matter and coloured compounds present in the water sample. It changes the colour of the water, retard the penetration of sunlight with decrease in photosynthetic activity and depletion of oxygen content and make the water unsuitable for use.

Odour - The smell or odour of the rice mill effluent was found to be unpleasant or foul. The offensive odour may be due to the volatile substances associated with organic matter and anaerobic decomposition by living organisms, principally microorganisms. The offensive odour impairs the water quality and causes nausea and vomiting.

Temperature - Temperature is the measure of hotness of any material. The measurement of temperature in water is important basically for its effects on the biochemical reactions in the living organisms. It is also important in the determination of pH, conductivity and saturation level of gases in water. In the present study the average temperature of rice mill effluent was about 38.0±5.09^{0}C with minimum being 35.0±0.39^{0}C(August) and maximum being 48±0.50^{0}C (June 1997)

TABLE - 1
Bimonthly variation in the physico-chemical characteristics of the effluent of a rice mill

Parameters	Month (1997)					
	Feb.	Apr.	June	Aug.	Oct.	Dec.
Colour	Brown			Light brown		
Odour	Unpleasant					
Temperature (^{0}C)	35.3 ±0.32	39.0 ±0.32	48.0 ±0.50	35.0 ±0.39	35.7 ±0.36	35.3 ±0.34
Conductivity (m mho/cm)	0.72 ±0.03	0.79 ±0.32	0.86 ±0.04	0.46 ±0.03	0.54 ±0.03	0.59 ±0.03
pH	8.0 ±0.01	8.4 ±0.05	8.8 ±0.07	7.2 ±0.1 2	7.8 ±0.11	7.9 ±0.15
Total Solids (mg/L)	1280.4 ±48.23	1350.3 ±52.15	1459.1 ±86.16	998.1 ±44.25	1032.1 ±33.01	1080.1 ±35.52
TSS (mg/L)	555.3 ±16.72	565.7 ±15.23	576.0 ±16.52	432.5 ±11.53	510.0 ±14.39	540.5 ±15.79
TDS (mg/L)	725.4 ±15.44	784.3 ±17.37	883.1 ±19.05	565.1 ±12.00	522.1 ±14.33	540.1 ±16.39
Dissolved oxygen (mg/L)	0.7 ±0.05	0.5 ±0.07	0.2 ±0.04	1.6 ±0.16	1.3 ±0.02	1.1 ±0.08
BOD at 20^{0}C (mg/L)	470.4 ±14.44	490.4 ±16.42	540.1 ±20.63	312.1 ±12.5	437.1 ±14.39	450.0 ±163.9
COD (mg/L)	675.2 ±15.49	763.4 ±16.39	892.1 ±18.53	400.2 ±12.32	480.2 ±13.66	568.9 ±19.72
Total Alkalinity (mg/L)	282.7 ±10.93	325.1 ±9.44	340.1 ±11.44	180.7 ±9.34	240.3 ±8.56	263.1 ±9.22
Total hardnes (mg/L)	205.3 ±8.44	230.3 ±10.49	256.4 ±14.3	98.3 ±7.42	134.1 ±8.21	167.7 ±7.43.
Ca hardness (mg/L)	90.2 ±5.43	94.4 ±5.32	98.3 ±.23	38.4 ±3.4	69.6 ±5.39	77.2 ±15.49
Mg hardness (mg/L)	21.4 ±1.66	23.2 ±2.27	24.3 ±1.96	14.1 ±1.59	20.2 ±1.08	22.9 ±2.14
Chloride (mg/L)	149.1 ±12.32	165.2 ±11.12	170.3 ±15.4	95.1 ±8.46	123.4 ±8.37	136.8 ±10.23
Sulphate (mg/L)	38.1 ±2.39	42.2 ±3.11	70.1 ±4.8	28.4 ±2.36	30.3 ±2.22	30.9 ±2.42
Phosphate (mg/L)	22.1 ±1.98	33.1 ±2.12	35.2 ±2.34	10.1 ±2.05	12.1 ±2.36	13.4 ±2.39
Nitrate (mg/L)	0.5 ±0.03	0.6 ±0.03	0.8 ±0.04	0.3 ±0.04	0.4 ±0.03	0.4 ±0.03
Sodium (mg/L)	242.5 ±9.52	250.2 ±8.36	263.7 ±9.22	213.4 ±5.32	215.2 ±6.11	225.0 ±5.31
Potassium (mg/L)	20.1 ±2.29	24.1 ±2.16	32.1 ±3.23	14.2 ±1.6	14.1 ±1.52	15.3 ±1.72
Phenols (mg/L)	43.2 ±3.94	45.1 ±3.1	50.4 ±4.93	13.3 ±1.45	25.2 ±3.32	32.8 ±3.11
SiO_2 (mg/L)	65.4 ±5.34	72.1 ±6.79	75.1 ±6.55	35.4 ±3.61	47.2 ±4.2	52.7 ±5.23

TABLE - 2
Physico-chemical characteristics of the effluent of a rice mill at Sambalpur, Orissa with their maximum permissible limits as recommended by Indian Standard Institution

Parameters	Range	Mean ±SD	ISI limit of discharge of industrial effluents	
			On land for Irrigation (ISI, 1977)	Into inland surface waters (ISI, 1974)
Colour		Brown	-	-
Odour		Unpleasant	-	-
Temperature (^{0}C)	35.0-48.0	38.0±5.09	-	40
Conductivity (μho/cm)	0.46-0.86	0.66±0.15	-	-
pH	7.2-8.8	8.0±0.54	5.5-9.0	5.5-9
Total Solids (mg/L)	998.1-1459.1	1200.0±189.48	-	-
TSS (mg/L)	432.5-576.0	530.0±53.00	100	100
TDS (mg/L)	522.1-833.1	670.0±1.49.2	2100	2100
Dissolved Oxygen (mg/L)	0.2-1.6	0.9±0.52	-	-
BOD at 20^{0}C(mg/L)	312.1-540.1	450.0±76.61	100	30
COD (mg/L)	400.2-892.1	630.0±183.03	-	-
Total Alkalinity (mg/L)	180.7-340.1	272.0±58.29	-	-
Total hardness (mg/L)	98.3-256.4	182.0±59.84	-	-
Ca hardness (mg/L)	38.4-98.3	78.0±22.22	-	-
Mg hardness (mg/L)	14.1-24.3	21.0±3.68	-	-
Chloride (mg/L)	95.1-170.3	140.0±28.06	600	1000
Sulphate (mg/L)	28.4-70.1	40.0±15.66	1000	1000
Phosphate (mg/L)	10.1-35.2	21.0±11.11	-	-
Nitrate (mg/L)	0.3-0.8	0.5±0.15	-	-
Sodium (mg/L)	213.4-263.7	235.0±20.34	60%	-
Potassium (mg/L)	14.1-32.1	20±7.12	-	-
Phenols (mg/L)	13.3-50.4	35.0±13.98	-	1.0
SiO_2 (mg/L)	35.4-75.1	58.0±15.5	-	-

Electrical conductivity (EC) - Electrical conductivity is the measure of the capacity of a substance or solution to conduct electricity. The concentrations of various ionic species in effluent or water are reflected through this parameter. The conductivity value was minimum during the month of August (0.46±0.03 m mho/cm) and maximum during the month of June 1997 (0.86±0.4 m mho/cm). The conductivity of the effluent on an average was 0.66±0.15 m mho/cm (Table 1 and 2).

pH - pH is the measurement of hydrogen ion concentration and it indicates instantaneously the intensity of acidity or alkalinity in water or effluent. It effects many chemical reactions and biological systems function only in relatively narrow pH ranges. The hydrogen ion concentration of water are influenced not only by the dissociation of water, but also by the relationship between the concentration of carbonic acid (H_2CO_3) and its ions (H^+, CO_3^{2-}) as well as by the generation of these ions from the humic acids and by the hydrolysis of heavy metal salts. From our observation it was found that the effluent of rice mill is highly alkaline in nature and the pH varies from 7.2 ±0.12 (August) to 8.8±0.07 (June 1997). The pH was within the tolerance limit of ISI (5.5 to 9.0) recommended for the discharge of industrial effluents on land for irrigation as well as into inland surface waters (Table 2).

Total solids (TS) - The soluble compound (both organic and inorganic) present in the effluent or waste water is generally called as dissolved solids and the insoluble matter as suspended solids. The sum total of suspended and dissolved solids is known as total solids. The dissolved solids, suspended solids and total solids in the rice mill effluent varied from 565.1±12.00- 883.1±19.05, 432.5±11.53-576.0±16.52, and 998.1±44.25-1459.1±86.16 mg/L during the study period with the average value being 670.0±149.20,530.0±53.00 and 1200.0±189.48 mg/L respectively (Table 1 and 2). All the solids were higher during summer season when the atmospheric temperature was maximum. The value of dissolved solids in the effluent were beyond the prescribed tolerance limit of ISI (100 mg/L) for the discharge of the industrial effluent on to land or into inland waters.

Dissolved oxygen (DO) - Dissolved oxygen is an important parameter to determine the water quality for various purposes. DO concentration in water indicates ability to support aquatic life. Clean surface water is normally saturated with DO of about 7.6 mg/L at 30^{0}C. Inorganic reductants such as ammonia, hydrogen sulphide, nitrite, ferrous ion and other oxidisable substances also tend to decrease DO content in water. In our study the DO content ranged from a minimum of 0.2±0.04 mg/L (June) to a maximum of 1.6±0.16 mg/L (August, 1997).

Biochemical oxygen demand (BOD) - BOD is measure of pollution created by organic matter present in the water. It is determined by calculating the amount of oxygen required by the microorganisms to stabilize the biodegradable organic matters. Biochemcial oxidation is a slow process and it takes 20 to 30 days for the complete degradation of the waste. However maximum oxidation is achieved in 5 days. In our study BOD content ranged from a minimum of 312.1±12.5 mg/L (August) to a maximum of 540.1±20.63 mg/L (June, 1997).

Chemical oxygen demand (COD) - COD is the measurement of oxygen consumed during the oxidation of organic matter present in water sample by a strong oxidizing agent. The organic matter includes biodegradable as well as chemically oxidizable matter, because of which COD is always greater than BOD. In our study the minimum COD value was recorded during the month of August (400.2±12.32 mg/l) and maximum was recorded during the month of June 1997 (892.1±18.53 mg/L). the COD of the effluent on an average was 630.0±182.03 mg/L (Table 1 and 2).

TABLE - 3

Physico-chemical characteristics of effluents of some major industries in India

Industries	pH	EC	DO	TS	TDS	TSS	CO_3	HCO_3	TH	CaH	MgH
Chemical	4.7	-	-	-	105.59	6.31	-	-	-	-	-
Chemical	5.03	-	-	1757	1549	108	Nil	Nil	628	-	-
Chloroalkali	1.7	-	-	2.9	2.85	0.05	-	-	-	-	-
Copper Wire Plant	0.3	-	-	72.5	71.25	1.25	-	-	-	-	-
Distilleries	4.4	-	-	67000	-	-	13.0	3956	-	-	-
Dyeing	9.5	-	-	5600	3600	2000	120	85.4	-	-	-
Food and Chemical	8.8	2.0	-	-	2938	294	-	-	-	-	-
Galvanizing Factory	3.6	4.2	-	2574	2194	380	-	-	590	260.0	106
Hindustan Aeronautics Ltd.	8.5	-	5.6	-	3312.7	188.3	-	-	-	-	-
Hindustan Machine Tools	8.3	-	4.9	-	14988.5	6139.5	-	-	-	-	
Olive Mill	5.17	5.5	-	-	-	-	-	-	-	-	-
Pulp and Paper	10.5	1.9	-	-	3750	1918	-	-	-	-	-
Sulphuric Plant	2.3	-	-	28.98	27.28	1.70	-	-	-	-	-
Tannery	5.6	5.48	-	21848	19364	2489	-	-	3262	-	-
Textile	9.4	2.4	-	-	214	-	-	-	-	-	-
UB-Mac Batteries	2.8	-	3.5	-	2790.0	2454.9	-	-	-	-	-
Rice Mill	8.0	0.66*	0.9	1200	670	530	-	-	182	78	21

Cont.......

Industries	Ca	Mg	Na	K	SiO_2	Cl	SO_4	H_2S	PO_4	NO_3	NH_3N
Chemical	-	-	50.0	-	-	1270	-	-	Nil	Nil	18.0
Chemical	201	30	56	14	-	553	389	-	-	Nil	-
Chloroalkali	-	-	180	16.0	-	2530	70.0	-	-	-	-
Copper wire Plant	-	-	420	280	-	50	Huge	-	-	-	-
Distilleries	3400	-	-	-	-	3520	69.5	-	38.8	-	51
Dyeing	-	-	99.5	0.48	-	18.46	-	-	16.4	-	-
Food and Chemical	213	99	73	47.6	-	1321	178	-	5.08	-	80
Galavanizing Factory	-	-	-	-	-	1068	348	-	-	-	-
Hindustan Aeronautics Ltd.	148.7	16.4	0.5	2902	0.2	1.0	292.2	0.6	19.0	2.2	32.2
Hindustan Machine Tools	191.5	112.5	284.7	366.0	1.0	6.7	3758.6	2.7	0.2	45.7	4.2
Olive mill	0.42	0.18	0.15	5.24	-	-	-	-	-	-	0.88
Pulp and Paper	264	193	560	7	-	146	70	-	Nil	-	3217
Sulphuric Plant	-	-	740.0	480	-	160	Huge	-	-	-	-
Tannery	-	-	-	-	-	1.44	-	-	-	-	-
Textile	87	112	19	100	-	750	642	-	1.0	-	346
UB-Mac Batteries	174.8	95.6	679.9	5.1	0.8	0.9	1738.3	0.6	1.5	2.2	3.1
Rice Mill	-	-	235	20	58	140	40	-	21	0.5	-

Cont......

Industries	BOD	COD	Fe	Zn	Al	Mn	Pb	Cd	Cr	Ni	Total
Chemical	34.65	113.09	-	1.1	-	-	-	-	-	-	-
Chemical	-	-	0.8	Nil	-	-	Nil	-	-	-	-
Chloroalkali	-	-	-	-	-	-	-	-	-	-	-
Copper wire Plant	-	-	2460	-	-	50	-	-	-	-	-
Distilleries	40000	-	-	-	-	-	-	-	-	-	-
Dyeing	-	300	Trace	Nil	-	Nil	-	-	-	-	-
Food and Chemical	6000	1671	6.0	0.7	-	-	0.87	0.02	0.01	-	-
Galavanizing Factory	-	606.1	250	195	28.8	17.6	5.78	3.0	1.48	0.516	
Hindustan Aeronautics Ltd.	-	2514	3.3	124.5	-	-	13.8	-	146.4	22.3	-
Hindustan Machine Tools	-	3000	82.4	22.5	-	-	13.6	-	134.2	116.8	-
Olive Mill	-	-	951	57	-	15	-	-	-	-	2.21
Pulp and Paper	3000	2104	8.0	0.87	-	-	1.29	0.03	0.01	-	-
Sulphuric Plant	-	-	1160	-	-	200	-	-	-	-	-
Tannery	8739	21965	-	-	-	-	-	-	-	-	-
Textile	6000	2032	20	3.0	-	-	0.85	0.02	0.01	-	-
UB-Mac Batteries	-	-	9.1	282.4	-	-	282.7	-	12.3	16.3	-
Rice Mill	450	630	-	-	-	-	-	-	-	-	35.0

All values are in mg/l except pH and EC, EC in ms/cm, (* m mho cm), Somashekar et.al. (1984), Siddaramaiah et. al. 1998), Srivastava and Sahai (1987), Swaminathan and Vaidheeswaran (1991), Agrawal and Pandey (1995), Madhappan (1993), Pillai et. al. (1996), Rani and Janardhan (1980), Panda and Sahu (1999).

Total alkalinity (TA) - Alkalinity of the water is its capacity to neutralize strong acid and is characterized by the presence of all hydroxyl ions capable of combining with the hydrogen ion. Alkalinity in natural waters is due to free hydroxyl ions and hydrolysis of salts formed by weak acid and strong bases, such as carbonate and bicarbonates. The total alkalinity of wastewater was varied from 189.7±9.34- 340.1±11.44 mg/L in our study.

Total hardness (TH) - Hardness is an important parameter to assay the quality of water, whether it is to be used for domestic, agricultural or industrial purposes. Principal cations imparting hardness are calcium and magnesium. However other cations such as iron, manganese, aluminium, barium and strontium also contribute to the hardness. The anions responsible for hardness are mainly bicarbonate, carbonate, sulphate and chloride etc. Hardness is temporary if it is caused by carbonate and bicarbonate salts of the cation. Permanent hardness is caused by sulphate and chloride of the metals. The calcium and magnesium hardness recorded in the present study were in the range of 38.4±3.40- 98.3±6.23 and 14.1±1.59- 24.3±1.96 mg/L, respectively. The total hardness was maximum (256.4±14.30 mg/L) in the month of June and minimum (98.3±7.42 mg/L) in the month of August 1997 (Table 1 and 2)

Chloride and Sulphate - Chloride and sulphate anions are commonly found in all types of water. In natural fresh water chloride concentrations is quite low and usually less than that of sulphate. Discharge of industrial effluent and domestic sewage in water tend to increase the concentrations of chloride and sulphate. The concentration of chloride and sulphate in the rice mill effluent was found in the range of 95.1±8.46-170.3±15.34 mg/L and 28.4±2.36- 70.1±4.8 mg/L respectively.

Phosphate - Phosphorus occurs in natural and wastewater almost as phosphate. The most important sources of phosphate are the discharge of domestic sewage, industrial waste and agricultural run-off. Phosphorus is essential to the growth of organism and can be the nutrients that limit the primary productivity of water pollution. The phosphate concentration of the rice mill wastewater varied from a minimum of 10.1±2.05 mg/L (August) to a maximum of 35.2±2.34 mg/L (June 1997) (Table 1).

Nitrate - Nitrate represents the highest oxidized form of nitrogen. The most important sources of nitrate is biological oxidation of organic substances, which come in sewage and industrial waste. Higher amount of nitrate is generally the indicator of pollution. Excess of nitrate in water causes diseases in animals and methamoglobinemia in blood. In the present study the nitrate content of rice mill waste water varied form 0.3±0.04 (August)- 0.8±0.04 mg/L (June 1997) with an average being of 0.5 ±0.15 mg/l.

Sodium - Sodium is one of the important cations present in water. It is highly soluble in water. Domestic sewage is one of the important sources of sodium. Sodium associated with chloride and sulphate makes the water unportable. Water with high sodium content is also not suitable for agriculture as t tends to deteoriate the soil for crops. In our study the sodium content of rice mill effluent varied from 213.4±5.32 to 263.7±9.22 mg/L with the average being 235.0±20.34 mg/L.

Potassium - Like sodium, potassium is also a naturally occurring element and remains in solution without undergoing any precipitation. The concentration of this element vary often remains lower than that of sodium, calcium and magnesium. In our study the potassium content ranged from a minimum of 14.1±1.52 mg/L (October) to a maximum of 32.1±3.23 mg/L (June, 1997) with average being 20.0±7.12 mg/L.

Phenol - Phenol imparts characteristics objectionable odour to the receiving water. They are well known disinfectants an hence resist biological activities and are toxic to soil and aquatic organisms. In our study the total phenol content of rice mill effluent was in the range of 13.3±1.45- 50.4±4.93 mg/L (Table 1).

Silica - The silica minerals are insoluble in low pH and their solubility does not increase if pH increased from 2 to 8. The dissolved silica in natural water is usually very small, ranging from 1-30 mg SiO_2/L. In the present study the silica content of rice mill effluent ranged between 35.4±3.61 mg/L and 75.1±6.55 mg/L with an average being 58.0±15.5 mg/L (Table 1 and 2)

DISCUSSION

Table-3 gives the physico-chemical characteristics of effluent of some major industries in India. From the table it is evident that the chemical nature of effluent generated from these industries differ widely from one another depending upon the type of industry, nature of raw material used and manufacturing process involved. The effluents of industries like textile, pulp and paper, food and chemicals and dying are alkaline in nature with high dissolved solids, COD and BOD which indicate the presence of enormous amount of organic substances. On the other hand the industries like distilleries, tannery, chemical, galvanizing factory and chloroalkalies generate acidic effluent with high BOD, COD, TDS and chloride. In the present investigator the effluent of rice mill industry of Sambalpur (Orissa) showed an alkaline pH (8.0). The alkaline pH of the effluent may be due to reaction of area and common salt with phenols released from rice during boiling operations. The area used to bring glaze of rice in boiler tank broken down to CO_2 and NH_3. The NH_3 in turn reacts with water and phenol to form ammonium, phenolate, which are basic in nature. Besides these reactions , the sodium ions of NaCL (common salt is used in the boiler tank to suppress the boiling point of water) also reacts with phenol to form an alkaline substance called sodium phenolate which again increases the pH. The concentration of DO (0.9 mg/L), nitrate (0.5 mg/L), phosphate (21 mg/L) and sulphate (40 mg/L); were low in the rice mill effluent with moderate concentration of COD (630 mg/L), chloride (140 mg/L) and TDS (670 mg/l). The total suspended solids (530 mg/L) and BOD (450 mg/L) were much higher than the recommended standard set by ISI (1974, 1977) for the discharge of industrial effluent into inland surface waters as well as on land for irrigation, which indicates the presence of high amount of organic matter in the effluent (Table 2). Moreover, the effluent was rich in sodium (23 mg/L), total phenols (35 mg/L) as well as silica (58 mg/L). The higher concentration of sodium in the effluent may be due to use of common salt in the boiler tank and the ingress of domestic sewage of the workers into the discharge outlet of the rice mill effluent. The higher values of phenolic compounds and silica in the effluent is perhaps because of boiling and cleaning operations involved in the processing of raw paddy.

The treatment of the effluent is therefore required to render the effluent suitable for discharge into inland surface waters. Further, the suitability of the effluent for agricultural use may be tried and if required necessary treatment of the effluent be made to render the effluent suitable for irrigation.

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