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Analysis and Treatment of Industrial Effluents of Balasore Town: A Way for Water Analysis and Management

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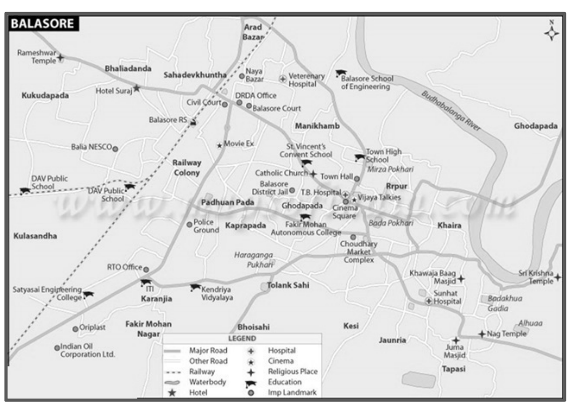
ABSTRACT

The effluent ejected from various industrial operations is acidic in nature and contains heavy metallic contaminates if it is not properly treated which causes greater impact on the quality of surface water near by the city area and people of Balasore town are adversely affected by it. The proper treatment of the waste water effluents increases the pH and decreases pollution load of effluents to an acceptable level and causes the decrease in pollution load of both surface and ground water. The samples were collected from different areas of Balasore town and the different parameters like pH, COD, Electrical conductivity (EC), Turbidity, chlorides, Sulphates, Phosphates Hardness etc. These were analyzed by using suitable methods at different intervals of time. It was observed that the pH varies from place to place and in most of the places the industrial effluents are found to be highly acidic in nature. The levels of other pollutants in most of the areas are found to be high but the pH was found to be low. High levels of pollutants in water interfere with aquatic organisms of surface water in the command area of Balarore town and disturb the ecosystem and life style of the people of this town. Adsorption is one of the methods for effective treatment of waste water effluents.

Graphical Abstract



Water analysis study area of Balasore Town

Keywords: Effluents, Adsorption, Treatment, Fly ash, Parameters.

INTRODUCTION

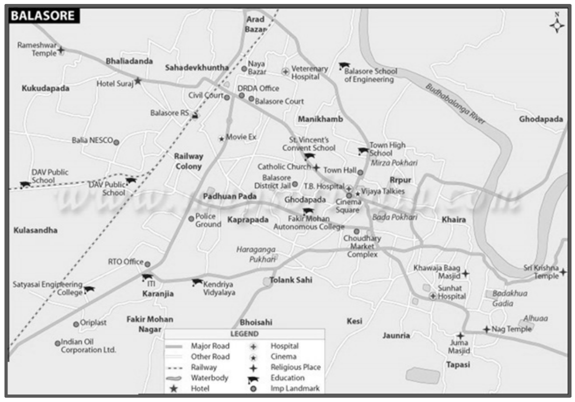
According to EPA the treated and untreated waste water that ejected from the different treatment plants, sewer and from the different areas of industrial sectors is known as waste effluents. It is a liquid waste or sewage which is discharged into the river and finally into sea causing increase in pollution load both in river water and sea. The pollution load is measured in terms of water quality index [1]. The elemental analysis indicates heavy metallic contaminates and acidic property of that water and other pollutants beyond the permissible limit [2]. After primary treatment only the suspended matters and some minor impurities are removed and then after that to remove some toxic impurities the effluent is treated again and the effluent after that treatment is called as secondary treatment of the effluent and it reduces the pollution load from the effluents [3]. The waste effluent water has adversely affected the quality of both surface and ground water by anthropogenic influences and also contains large amounts of dissolved solids(DS), suspended solids(SS), both biodegradable and non-biodegradable organic and inorganic waste materials along with huge amount of a number and type of pathogenic bacteria, Virus [4, 5]. There are more than 30 medium and small scale industries including paper mills, plastic industries, rubber industries like Birla Tyres, packaging industries etc. are operating in the Balesore town [6, 7]. The industrial discharge contains alcohols chelating agents and inorganic materials like chlorates and transition metal compounds, the presence of nutrients in the effluents such as Nitrogen and Phosphorus causes eutrophication in fresh water bodies such as rivers, lakes and other water reservoirs [8]. The organic matter present in the industrial effluents and urban effluents increase BOD content in the surface water and cause of ecological imbalance in fresh water bodies. The various toxic chemicals of industrial wastes from paper mills and fertilizer industries, plastic industries mixed with surface water and causes health hazard problems of the people of Balesore town [9, 10] The industrial waste water also contains high amounts of fluorides and chlorides in addition to toxic chemicals causing health hazard effects. Hence waste water effluents and sewage water ejected from various industries of Balesore town are considered as the most dangerous and large source of surface water pollution nearby that area due to the presence of huge quantities of bacteria, viruses, organic, chemical compounds such as soap, detergents, oil, biomedical effluents, inorganic compounds along with biodegradable and non-biodegradable waste, plastic material and a no. of different kinds of heavy metals. [11] .This is the cause of destroying some of the rare species of plants and animals and aquatic organisms. from the ecosystem in the command area of Balesore town. Hence in order to avoid such types of problems and environmental hazards it is necessary to treat the waste water in adequate water treatment technology properly and then it is to be dumped into the river or any water bodies safely It was found that among the various treatment methods the process of adsorption by using a waste material fly ash is a good technique for decreasing the pollution load from industrial effluents and it can be safely discharged to the surface water bodies [12].

Meteorological Factors of Balesore Town

Rainfall Pattern and Temperature: There is an extreme climatic condition in Balesore town and nearby that area. The average annual rainfall of that area is 1613.6 mm and the average temperature in summer is in between 43.8°-33°C and in winter is 11.5°- 6.3°C. However, in summer the maximum temperature goes as high as 45.4°C during day and in winter minimum temperature may fall down to 3.1°C. [13]

Wind Direction and Wind Velocity: During winter season wind flows mostly from East to West and in summer season wind flows mostly from North-East. The speed of the wind varies during day and night and also there is seasonal variation of the speed of the wind. On an average the wind speed varies from 8 KM h^{-1} to 20 KM h^{-1}[13].

Study Area: Balasore is one of the coastal districts of Northern Odisha, which is found at the eastern part of India. It is bounded by Bay of Bengal in the East, Mayurbhanja district in the west, Medinapur in the North and Bhadrak district in South Balasore lies in the east direction in the state and it has an area of around 4,075 sq.km.



Water analysis study area of Balasore Town

MATERIALS AND METHODS

The Physico-chemical studies of different parameters of the industrial effluents and sewage water were studied by means of proper conventional methods available in the literature. The water samples from effluent discharge drain of different industries were collected in the proper sampling clean polythene bottles and then the different physical and chemical parameters are studied in the laboratory within 24 h and rest was stored in a refrigerator for further analysis. The Physico-chemical parameters like pH conductivity, TA, TDS, TSS, TH, sulphate, phosphate, COD and hardness (both Ca and Mg hardness) were analyzed as per standard method given in literature [**14**].

Adsorption studies for treatment of waste effluents: A number of conventional treatment technologies have been considered for treatment of industrial effluent waste water contaminated with various organic and inorganic substances along with toxic heavy metals [**15, 16**] Among these adsorption process by using fly ash is found to be most effective and cheapest and innovative method for treatment of industrial waste effluents. Commercial activated carbon is regarded as the most effective material for controlling the various parameters but it is very costly so that the non-conventional adsorbents like fly ash, peat, lignite, sawdust, wood etc. have been widely used for the removal of refractory materials and colloidal particles for varying degree of success. After preparation of the absorption column, it was placed in the Laboratory at room temperature condition for carry out the experiments. Before the absorption experiment, the drain pipe was blocked by rotating the stopper. Prior to each experiment different amounts of fly ash i.e. 5g, 10 g, 20 g was taken in a 500 mL test absorption tube. Then 250 mL of industrial effluent water was added into it and stirred for about 5 - 10 min in order to proper mixing and then it was kept for 8 h and 24 h for absorption study. All these experiments are carried out at different pH conditions and at different concentration of absorbing materials. After each absorption experiment the sample water from the absorption column was passed through the filter column containing activated bamboo charcoal and fine sand as the filter media. Finally, it was filtered by a whatman-42 filter paper.

RESULTS AND DISCUSSION

The composition of fly ash shows its siliceous nature followed by insoluble oxides of aluminium, iron, calcium and magnesium. In the case of fly ash as an adsorbent, the metal salts hydrolyze in the presence of natural alkalinity to form metal hydroxides. The multivalent cations present in fly ash can reduce the zeta potential while the metal hydroxides are good adsorbents. It forms monomolecular layer on the surface of suspended organic matter and removes it by enmeshing these and settling.

When the above industrial effluent water was adsorbed over fly ash and adsorption study was done it will found that the quality of effluent water improved satisfactorily and useful for irrigation purpose. Other advantage of fly ash is that it could easily be solidified after the pollutants are absorbed by it because it contains pozzolanic particles that react with lime in the presence of water forming calcium-silicate hydrates. Since fly ash contains zeolite, therefore it can be used successfully for treatment of water and waste water also (Table 1-4).

Table 1. (Physico-chemical characteristics of industrial effluent water (Before treatment)

Parameters	Values	Parameters	Values
pH	4.6	Chloride	310
Color (apparent)	Light brown	Sulphate	295.56
Electrical Conductivity (µmho cm^{-1})	1980	Phosphate	0.45
Turbidity (NTU)	8.8	Total Hardness	481
Total Alkalinity	480	Calcium hardness	273.7
Total dissolved solid	1005	Magnesium hardness	207.3
Total suspended solid	615	Chemical Oxygen Demand	487

All values are reported in mg L^{-1}, except pH (otherwise stated)

Table 2. Physic-chemical characteristics of the industrial effluent water after treatment at lower pH range

Parameters	Contact time- 8 h					
	20 g FA L^{-1} of EW	Value increase/ Decrease in %	40g FA L^{-1} of EW	Value increase/ Decrease in %	80g FA L^{-1} of EW	Value increase/ Decrease in %
pH	5.4	37.20	5.9	31.39	6.8	20.93
Color (apparent)	Light orange	Partial	Transparent	100	Transparent	100
EC (µmoh cm^{-1})	1992	0.60	2017	1.86	1972	0.40
Turbidity (NTU)	5.1	25.0	6.1	10.29	6.1	10.29
TA	264	54.48	226	61.03	192	66.89
TDS	794	26.21	728	34.40	702	37.63
TSS	Absent	100	Absent	100	Absent	100
Chloride	98.02	18.28	96.08	35.09	94.2	4.50
Sulphate	102.24	41.76	96.84	44.83	68.88	60.76
Phosphate	0.152	0.66	0.158	4.63	0.114	24.50
TH	252	45.90	224	55.87	218	58.00
Ca hardness	150.5	5.95	112.5	7.26	110.5	27.93
Ma hardness	101.5	9.00	11.5	10.01	107.5	18.33
COD	216	14.97	268	18.84	214	25.60
Parameter	**Contact time- 24 h**					
	20g FA L^{-1} of EW	**Value increase/ Decrease in %**	**40g FA L^{-1} of EW**	**Value increase/ Decrease in %**	**80g FA L^{-1} of EW**	**Value increase/ Decrease in %**
pH	5.5	36.04	6.1	29.06	7.2	16.27
Color (apparent)	Light greyish	Partial	Transparent	100	Transparent	100
EC(µmoh cm^{-1})	2000	1.01	2018	1091	1893	4.39
Turbidity NTU)	4.8	29.41	4.9	27.94	5.7	16.17
TA	204	64.82	200	65.51	186	67.93
TDS	762	30.18	712	36.39	690	39.13
TSS	Absent	100	Absent	100	Absent	100
Chloride	70.08	29.64	88.12	10.02	68.06	46.39
Sulphate	94.28	46.29	64.02	63.53	38.72	77.94
Phosphate	0.102	32.45	0.098	35.09	0.071	52.98
TH	206	62.27	211	65.83	198	68.68
Ca hardness	104.5	9.31	110.5	25.3	101.5	37.24
Ma hardness	101.5	11.15	100.5	34.48	96.5	49.15
COD	264	20.77	283	40.57	208	48.82

All values are reported in mg L^{-1}, except pH (otherwise stated), values increased after treatment, RT- room temperature, FA- Fly ash, EW: Effluent water.

Table 3. Physic-chemical characteristics of the industrial effluent water after treatment at neutral condition

Parameters	Contact time- 8 h					
	20 g FA L^{-1} of EW	Value increase/ Decrease in %	40g FA L^{-1} of EW	Value increase/ Decrease in %	80g FA L^{-1} of EW	Value increase/ Decrease in %
pH	7.1	17.44	7.3	15.11	7.8	9.30
Color(apparent)	Light orange	Partial	Transparent	100	Transparent	100
EC (µmoh cm^{-1})	1985	0.25	2000	1.01	1960	1.01
Turbidity NTU)	5.0	26.47	5.1	25.0	5.1	25.0
TA	408	29.65	318	45.17	294	49.31
TDS	602	25.21	616	23.47	634	21.24
TSS	Absent	100	Absent	100	Absent	100
Chloride	76.01	7.05	82.14	15.69	88.2	24.22
Sulphate	100.21	42.91	104.86	40.27	165.93	5.48
Phosphate	0.138	8.60	0.131	13.24	0.119	21.19
TH	264	6.04	259	7.82	240	14.59
Ca hardness	51.2	4.65	49.3	8.19	49.1	8.56
Mahardness	53.27	3.51	51.08	7.48	54.16	1.90
COD	201	2.81	198	4.34	185	10.62
Parameter	**Contact time- 24 h**					
	20g FA L^{-1} of EW	Value increase/ Decrease in %	40g FA L^{-1} of EW	Value increase/ Decrease in %	80g FA L^{-1} of EW	Value increase/ Decrease in %
pH	7.6	11.62	7.9	8.13	8.4	2.32
Color (apparent)	Light grayish	Partial	Transparent	100	Transparent	100
EC(µmoh cm^{-1})	1988	0.40	2008	1.41	2025	2.27
Turbidity NTU)	4.9	27.94	5.0	26.47	5.0	26.47
TA	390	32.75	292	49.65	426	26.55
TDS	598	25.71	604	24.96	688	14.53
TSS	Absent	100	Absent	100	Absent	100
Chloride	36.06	49.21	80.24	13.01	102.04	43.71
Sulphate	96.26	45.16	98.63	43.81	142.38	18.89
Phosphate	0.127	15.89	0.122	19.20	0.116	23.17
TH	241	14.23	237	15.65	221	21.35
Ca hardness	52.9	1.48	54.6	1.67	61.3	14.15
Ma hardness	52.18	5.48	49.26	10.77	59.71	8.15
COD	192	7.24	180	13.04	196	5.31

All values are reported in mg L^{-1}, except pH (otherwise stated), values increased after treatment, RT- room temperature, FA- Fly ash, EW: Effluent water.

Table 4. Physic-chemical characteristics of the industrial effluent water after treatment at higher pH range

Parameters	Contact time- 8 h					
	20g FA L^{-1} of EW	Value increase/ Decrease in %	40g FA L^{-1} of EW	Value increase/ Decrease in %	80g FA L^{-1} of EW	Value increase/ Decrease in %
pH	8.9	3.48	9.0	4.65	9.6	11.62
Color(apparent)	Light orange	Partial	Transparent	100	Transparent	100
EC (µmoh cm^{-1})	1995	0.75	2010	1.51	1920	3.03
Turbidity NTU)	5.1	25	5.1	25	5.3	22.05
TA	588	1.37	596	2.75	624	7.58
TDS	456	43.35	424	47.32	398	50.55
TSS	Absent	100	Absent	100	Absent	100
Chloride	34.02	52.08	28.84	59.38	20.62	70.95
Sulphate	137.28	21.80	174.25	0.74	182.08	3.71
Phosphate	0.143	5.29	0.145	3.97	0.149	1.32
TH	280	0.35	291	3.55	295	4.98
Ca hardness	50.21	6.49	52.13	2.92	55.28	2.94
Mahardness	56.27	1.91	58.43	5.83	58.97	6.81
COD	300	3.38	306	0.48	318	5.31

Parameter	Contact time- 24 h					
	20g FA L^{-1} of EW	Value increase/ Decrease in %	40g FA L^{-1} of EW	Value increase/ Decrease in %	80g FA L^{-1} of EW	Value increase/ Decrease in %
pH	9.2	6.97	9.4	9.30	10.2	18.60
Color (apparent)	Transparent	100	Transparent	100	Transparent	100
EC(µmoh cm^{-1})	2025	2.27	2048	3.43	1808	8.68
Turbidity NTU)	5.0	26.47	5.4	20.58	5.9	13.23
TA	584	0.68	618	6.55	684	17.093
TDS	438	45.59	406	49.56	362	55.03
TSS	Absent	100	Absent	100	Absent	100
Chloride	30.86	56.53	32.04	54.87	18.28	74.25
Sulphate	129.36	26.31	181.06	3.13	197.84	12.69
Phosphate	0.153	1.32	0.158	4.63	0.241	59.60
TH	280	0.35	293	4.27	307	9.25
Ca hardness	52.06	3.05	56.23	4.71	61.42	14.37
Ma hardness	55.94	1.32	59.85	8.40	63.47	14.96
COD	204	1.44	319	5.79	389	39.61

All values are reported in mg L^{-1}, except pH (otherwise stated), values increased after treatment, RT- room temperature, FA- Fly ash, EW: Effluent water.

It is observed that before treatment the waste water effluents ejected from different industries of Balesore town is acidic in nature having pH value of 4.6. The electrical conductivity, TDS, TSS, Chlorides, sulphates, phosphates, hardness, COD are much higher than permissible limit. After treatment by using flyash as adsorbent, the pH increases and other parameter such as TSS TDS sulphates, phosphates, hardness and COD are reduced to an appreciable amount then rendering the effluent water to its permissible limit of discharge standard. It is found that the pollution load gradually decreases with increase in contact time of the effluent water with fly ash. This result is reflected from table1-4. Hence flyash can be used as a magnificent material for waste water effluent treatment.

APPLICATION

The generation of huge amount of fly ash from different industrial sectors is a headache for environmentalist all over the world. In this work we are using flyash as an adsorbent which can give a better path for its utilization in an eco-friendly manner for treatment of industrial waste effluent water. Therefore the surface water contamination both due to flash and industrial waste effluent water can be drastically reduced. This work may be applied in different industrial sectors of the world by using bulk amount of flyash. Hence the people not only of Balesore town but also in near area of other industrial sectors are benefited due to reduction of surface water pollution.

CONCLUSION

Adsorption is a useful alternative to conventional systems for the removal of contaminants from the industrial wastewater. Adsorption power can be enhanced by using acid or alkali treated adsorbents. By using low cost materials such as fly ash as adsorbents the adsorption process can be made economical. The waste water after the adsorption can be recycled again and used for irrigation, industry, landscaping and toilet flushing as a solution to water scarcity and to conserve our fresh water resources. Recycled waste water can also be used for recharging ground water to increase water level and for stability of our ecosystems. It is revealed from the study that if industrial effluent treated by fly ash generated from ferro-alloy plants then it reduces the excess value of physico-chemical parameters, which is harmful for people living in these areas. On analysis it is found that most of the parameters are much higher than the permissible limit but these parameters can be reduced up to maximum extent after absorption treatment. In acidic condition the parameters like suspended solid, total solid can be removed to a larger extent. The parameters like COD, is reducing upto 49% in acidic condition. Alkalinity, turbidity and hardness in acidic condition removed to a large extent making water suitable for common use. The parameter like phosphate increases on alkaline condition, which is not harmful; rather it improves the water quality for irrigation. If industrial management think about this and made necessary arrangement for treatment of industrial effluent with fly ash by pouring fly ash in some effluent treatment tank and allowing effluent to percolate through the fly ash pit before throwing directly to nearby area, then the harmful nature of the effluent will be reduced along with eco-utilization of fly ash and it becomes beneficial to our society.

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