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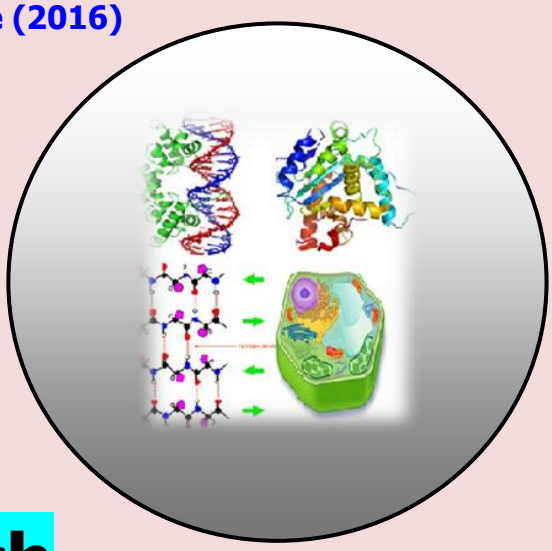

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RESEARCH PAPER

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Studies on the Impact of a Paper Mill Effluent on the Hydrography of the River Cauvery Pallipalayam near Erode, Tamil Nadu, India

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ABSTRACT

The present study perceives that paper mill effluents of Pallipalayam near Erode have substantial level of temperature, pH, hardness, alkalinity, free carbon dioxide, dissolved oxygen, biological oxygen demand, chemical oxygen demand, oil and grease and phenolic compounds. The water samples were collected from the river Cauvery, Pallipalayam near Erode in six different sampling points during post monsoon and summer for well-organized sampling and interpretation. The data indicates that pollution effect of the effluent is more severe particularly during post monsoon and summer seasons which results alteration in physico-chemical parameter of Cauvery river water. The study revealed that the pollution effluent deteriorated the quality of Cauvery river water, thereby affecting the normal aquatic life in the riverine ecosystem.
Keywords: Cauvery River, Pallipalayam, Paper mill effluents and Physico-chemical analysis.

INTRODUCTION

Industries are major sources of pollution in all environments. Based on the type of industry, various levels of pollutants can be discharged into the environment directly or indirectly through public sewer lines. Wastewater from industries includes process wastes from manufacturing industries, wash waters, employees sanitary waste etc. Pollutants includes disease causing microorganisms, organic pollutants, fertilizers, detergents, organic solid matter, oil, high concentration of dissolved salts, heavy metals, colour, foam, heat, toxic chemicals, carcinogenic compounds and radioactive materials etc., (Matsuo *et al.,* 2001; Emongor *et al.,* 2005; Mukhejee *et al.,* 2006). Pollution occurs when the discharge of wastewater consists of some or all of the above substances which impair the quality of natural ecological balance and in its broadest sense includes all changes that curtail natural utility and exert deleterious effect on life.

Industrialization results in the entry of a variety of chemicals to our environment (Bose, 1988). Natural waters are the ultimate recipients of most of the chemical wastes generated by man's industrials, agricultural and domestic activities (Anderson and D'Apollonia, 1978). Unlike domestic sewage, the industrial waste is very difficult to generalize and it varies from industry to industry. Mason (1981) considered that, normally an effluent consists of a variety of potentially harmful substances and most water courses will receive a number of effluent discharges, so that the effects of these will often be difficult or impossible to disentangle. Effluents released from industries such as pulp and paper industry, tannery industry, distillery units, dyeing and textile mills have been a major concern in causing water pollution in India. These effluents, when discharged in large quantities into the nearby water bodies, are known to cause alternation in the hydrographical parameters of

the water thereby causing tremendous damage to the harmonious ecosystem of the water bodies (Gundala Madhusudana Rao, 2006).

Hydrology of river water in relation to industrial pollution indicated that a general and seasonal survey of river waters to assess their water quality when compared to the hydrography in relation to effluent pollution. Seasonal changein the hydrographical parameters of Muriganga river showing altered water quality was investigated by Mukherjee *et al* (2006). Mathew Thomas *et al* (2006) evaluated the role of physico-chemical parameters of major perennial wetland of Karnataka. Disposal of Sewage, Industrial wastes and other human activities effects of Cauvery river were highly polluted **(**Venkatachalapathy and Karthikeyan, 2013). The detergents, starches and other chemicals generate toxic metabolites which are poisonous to fish and other aquatic animals (Sun and Hu*,* 2014). Synthetic dyes and other chemicals are complex substances most of them produce an adverse effects on all forms of living/non-living things. The chemicals are discharged as waste water and contribute to the effluents strong colour, high temperature, turbidity, varying pH, high biological oxygen demand (BOD) and chemical oxygen demand (COD) levels, increased turbidity, high level of suspended solids and total dissolved solids and the toxic nature of the effluents proves fatal to the aquatic organisms directly or indirectly (Elango*,* 2017).

The Cauvery river water flow depends on seasonal rains, which has been observed to be low. Besides industrial effluents, the domestic and agricultural run-off are also freely allowed to mix with the river water. Consequently, the quality of water in the Cauvery river has to be monitored and assessed periodically. The present investigation was aimed to know the effect of paper mill effluents on water quality of affected region.

MATERIAL AND METHOD

Study area and sample collection

Seshasayee paper mill discharges the paper mill effluent along the eastern bank of the Cauvery river, Pallipalayam (11^0 20.9635' N 770 45.2311' E), near Erode, Tamil Nadu, India. The surface water samples from six different spots I – Spot before mixing of paper mill effluent, IIa – Spot of mixing of paper mill effluent (a), IIb – Spot of mixing of paper mill effluent (b), III – Spot after mixing of paper mill effluent (a and b), SSPMa – Paper mill effluent (a) released from the mill and SSPMb – Paper mill effluent (b) released from the mill. The samples were collected on 1^{st} and 15^{th} days of every month during post monsoon (January – March 2006) and summer season (April – June 2006). Three litre of sample water and effluents from each spot were collected in clean plastic cans and stored at 4°C for physiochemical analysis.

Physicochemical analysis

The collected samples were subjected to analyses of physicochemical parameters such as temperature, pH, total alkalinity,hardness, free carbon dioxide (CO_2),dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), oil and grease and phenolic compounds as per standard methods (APHA, 1998) which listed in table 1.

STATISTICAL ANALYSIS

Data are presented as the mean ± SEM and were statistically analyzed by two-way analysis of variance (ANOVA) and the individual comparisons between spots and seasons were obtained by Duncan's multiple range test.

RESULTS AND DISCUSSION

In the present investigation changes in the different physicochemical parameters such as temperature, pH, total alkalinity,hardness, free carbon dioxide (CO_2), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), oil and grease and phenolic compounds in water samples collected at different spots and paper mill effluents are presented in Table 2.

Temperature plays a vital role in the physico chemical and biological activities of water bodies. Of the water sample collected at four destinations (Spot I, IIa, IIb, III) a maximum temperature of the stations recorded were 32.00 ± 0.37^oC at spot I during summer season and minimum temperature of 28.17 ± 0.48^oC was recorded at spot IIb also during this season. Ravikumar et al (2006) also reported that higher temperature during summer in the Harnapalli, Kulahalli tank in Karnataka. The fluctuation in river water temperature usually depends on the season, geographic location, sampling time and temperature of effluents entering the stream (Ahipathy, 2006). Based on the statistical analysis changes in temperature between spots were observed to be significant.

The temperature at spot I and III were found to be significant from that of spots IIa and IIb during summer and post monsoon season. Within the effluents SSPMa and SSPMb, the temperature change was significant during post monsoon season.

Table 1. List of methods, instrument/apparatus and units of expression of the different physicochemicals parameters estimated in the present study

Sl. No.	Parameters	Method adopted	Instrument/Apparatus used	Units of expression
1	Temperature	Direct measurement at the spot	Centrigrade mercury thermometer	^{o}C
2	pH	Direct measurement at the spot	Pen type pH meter pH scan 1^{TM}, Eutach Cybernetics, Singapore	pH Scale
3	Turbidity	Nephlometric method	Turbidity meter	NTU
4	Total alkalinity	Titration method	Standard apparatus used for titration	mg $CaCO_3$/l
5	Hardness	EDTA – Titrimetric method	Standard apparatus used for titration	mg $CaCO_3$/l
6	Free CO2	Titration method	Standard apparatus used for titration	mg/litre
7	DO	Modified Wrinkler's method	Standard apparatus used for titration	mg/litre
8	COD	Open-Reflux method	Standard apparatus used for titration	mg/litre
9	BOD	5-Day BOD test	BOD incubator	mg/litre
10	Oil and grease	Extraction method	Separating funnel and evaporating dish	mg/litre
11	Phenolic compounds	Chloroform extraction colorimetric method	Separating funnels and spectrophotometer	mg/litre

The pH of most natural water falls within the range of 4 to 9 and most of the water are slightly alkaline due to presence of carbonates and bicarbonates (APHA, 1998). The observed alkaline range of pH value ranging from 7.12 ± 0.35 to 7.78 ± 0.13 for effluents at different spots along the course of the Cauvery river at the site of Seshasayee paper mill. The changes in pH values were found to be highly significant between season, between spots and between seasons and spots.

A sudden appearance of increased turbidity in a water body is an indication of pollution from the nearby sources (Gupta and Pankaj, 2006). As turbidity is a function of total suspended solids and total dissolved solid, a more or less uniform trend could be observed in this parameter at different spots of examination. The presence of higher levels of turbidity at spot SSPMa and SSPMb during post monsoon and summer seasons, indicate the higher pollution effect of the paper mill effluent. The total alkalinity level of SSPMa effluent was more than that of SSPMb effluent. This higher total alkalinity of SSPMa was well reflected by the water at spot IIa, where a higher total alkalinity was observed than that at spot IIb. The high levels of total alkalinity indicates the deterioration of the water quality in all the station investigated, similar physic-chemical changes was reported by Gupta and Pankaj(2006).

The change in the hardness of river water by the discharge of effluent at the site of the paper mill was observed in the present study. The total hardness of the effluent SSPMa is greater than that of SSPMb during the different seasons of the study period. Similarly, the spot IIa also showed higher total hardness than that of spot IIb. Higher levels of hardness as a function of increased carbonate content was reported by Samuel Paul Raj (1982). The absence of similar trend in the fluctuations of total hardness at different spots during different seasons indicates that the fluctuations are more function of the manufacturing process of the mill than the climatic differences during seasons.

Table 2. Physicochemical parameters of water samples collected from the different spots along the Cauvery river at the site of paper mill

Parameters		I (Control)	IIa	IIb	III	SSPMa	SSPMb
Temperature	P	31.00 ± 0.61*	30.17 ± 0.39	29.33 ± 0.51	31.83 ± 0.24	29.00 ± 0.20	28.17 ± 0.33
	S	32.00 ± 0.37	28.83 ± 0.31*	28.17 ± 0.48*	31.83 ± 0.48	29.17 ± 0.48	29.33 ± 0.49
pH	P	8.44 ± 0.39**	7.43 ± 0.10	7.52 ± 0.12	7.70 ± 0.19	7.43 ± 0.039	7.12 ± 0.35**
	S	8.32 ± 0.09	7.78 ± 0.13	7.56 ± 0.11	7.35 ± 0.45	7.13 ± 0.194*	7.14 ± 0.66
Turbidity	P	1.78 ± 0.24	28.50 ± 8.05	65.83 ± 8.66**	3.20 ± 0.58	56.50 ± 10.03	77.67 ± 2.34**
	S	2.68 ± 0.16	45.33 ± 3.53**	56.83 ± 4.66	5.17 ± 1.27	62.83 ± 3.27	66.50 ± 5.21
Total alkalinity	P	212.67 ± 34.19*	509.33 ± 12.39	201.67 ± 9.33	236.67 ± 2.16*	507.50 ± 4.52	257.83 ± 4.98
	S	148.67 ± 11.91*	405.83 ± 31.26**	115.33 ± 3.33**	209.50 ± 2.26	438.18 ± 9.55**	266.83 ± 8.95
Hardness	P	131.17 ± 3.36	512.83 ± 35.90	172.33 ± 5.39	214.83 ± 23.36*	613.33 ± 12.24*	624.67 ± 14.83
	S	112.67 ± 11.49	443.33 ± 34.53**	144.66 ± 5.17	205.00 ± 8.48	606.00 ± 21.82	596.00 ± 71.31
Free CO2	P	BDL	163.83 ± 21.68**	65.80 ± 9.15	BDL	103.50 ± 4.73**	77.00 ± 7.82
	S	BDL	122.83 ± 18.03*	75.17 ± 5.00	BDL	89.67 ± 9.82	55.83 ± 9.08
DO	P	7.35 ± 0.05	Absent	Absent	7.40 ± 0.06	Absent	Absent
	S	7.12 ± 0.10	Absent	Absent	7.10 ± 0.07	Absent	Absent
COD	P	53.50 ± 8.42	311.00 ± 20.97**	91.83 ± 30.98	25.17 ± 9.00	404.00 ± 36.33	825 ± 90.72**
	S	53.67 ± 9.76	173.50 ± 21.76**	173.83 ± 15.33	26.83 ± 2.18	334.83 ± 24.18	579 ± 23.87**
BOD	P	10.17 ± 1.90	59.00 ± 2.41**	20.17 ± 4.50	5.47 ± 0.23	115.00 ± 9.86**	137.67 ± 5.92**
	S	4.85 ± 0.98	47.83 ± 3.41	18.67 ± 1.76	6.08 ± 0.63	104.00 ± 5.79	121.00 ± 9.40*
Oil and grease	P	BDL	10.83 ± 1.17**	2.72 ± 0.40	BDL	11.67 ± 1.31	22.50 ± 2.70**
	S	BDL	10.67 ± 1.41	1.88 ± 0.14	BDL	8.67 ± 0.92	19.33 ± 0.61
Phenolic compounds	P	0.07 ± 0.004	0.11 ± 0.003	0.16 ± 0.004	0.43 ± 0.002	0.24 ± 0.006	0.34 ± 0.007
	S	0.03 ± 0.007	0.05 ± 0.001	0.06 ± 0.002	0.02 ± 0.002**	0.70 ± 0.005**	0.10 ± 0.008

** - High significant (P< 0.01), * - Significant (P < 0.05), P – Post monsoon, S – Summer,
BDL – Denotes below detectable level.

The observed below detectable level of free CO_2 content at spots I and III in the seasons is in conformation with the quality of river water system. The levels of CO_2 content were very high in spots IIa and IIb during post monsoon and summer seasons. There is a decline in the CO_2 content of water sample as well as of the effluents particularly during summer season. During post monsoon season, elevated levels of CO_2 content were observed. Dissolved oxygen is an important constituent of water bodies and its concentration in water is an indicator of prevailing water quality and ability of water body to support a well balanced aquatic life (Vijayakumar *et al*, 2014). The complete absence of DO content in spots IIa and IIb together with oxygen free effluents, SSPMa and SSPMb appear to be a notable finding on the pollution effect of the paper mill effluent in the Cauvery river at site of the mill. SSPMb comparatively showed higher levels of COD than that of SSPMa with maximum values recorded during post monsoon season in the both the effluents. Low levels of COD were recorded at both spots I and III. Whereas, higher levels of COD were recorded at the spots IIa and IIb of mixing effluents. The high value of COD indicates high potency of organic as well as inorganic pollution in the water (Dasgupta *et al*., 2001).

The high BOD may deplete dissolved oxygen, causing death of aerobic organisms and increase anaerobic properties of water (Jody and Dons, 2003). Similar to the levels of COD, BOD levels are also comparatively higher in SSPMa and SSPMb followed by the levels of the spots IIa and IIb of mixing effluents with minimum values at spot I and III. The mean differences in the levels of BOD in spots IIa, SSPMa and SSPMb respectively were highly significant during post monsoon and summer seasons. BOD reveals the content of microorganisms present in the sample and its organic matter load.

Of the two effluents collected, SSPMb showed comparatively higher levels of oil and grease content which was very much in conformity with physical observation of oily nature released from paper mill. The complete absence levels of oil and grease at spot I and III indicate quality nature of water. During post monsoon and summer, SSPMa showed comparatively higher levels of phenolic compounds. The discharge of paper mill effluents alters the hydrography of the river Cauvery at the site of discharge as well as along the course of the downstream.

CONCULSION

In the present investigation, the results on the estimation of the physic-chemical parameters of water samples and effluents revealed that pollution effect of the paper mill effluent is more as function of inorganic salts which is responsible for the onset of severe chemical and biological oxygen demands, there by resulting the depletion of dissolved oxygen content. The study also indicates that the pollution effluent deteriorated the quality of Cauvery river water, thereby affecting the normal aquatic life in the riverine ecosystem.

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