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ENVIRONMENTAL IMPACTS OF VALAICHCHENAI PAPER MILLS EFFLUENT

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Abstract

The paper mill situated at Valaichchenai in the Eastern province provides most of Sri Lanka's requirement of paper. A general opinion among the public is that, the effluent from the Valaichchenai paper mill pollutes the lagoon. Therefore, a necessity arose to monitor the level of pollution in the Valaichchenai lagoon.

Samples were collected at a distance of about 10 m from the shore and at a depth of two feet for a period of seven months (September 96 - March 97) from raw water (Vahaneri)which is used for the paper manufacture, paper machine outlet and Valaichchenai lagoon where paper machine outlet is mixed. The pH, conductivity, salinity and turbidity were measured by using portable meters. Standard methods were used in the determination of anions, total suspended solids (SS), trace elements, dissolved oxygen and biological oxygen demand (BOD).

The results of the analysis elucidate that, the parameters such as pH, salinity, BOD, the anions (S^{2-}, F^-, NO_3^-, PO_4^{3-}) and the concentration of trace elements were within the tolerance level in all the samples tested. Dissolved oxygen (DO) concentration (6.2-6.5 mg/l) was in the tolerance range for lagoon and raw water. Lagoon sample show high turbidity (>500 mg/l) and this condition may be a drawback for the survival of prawns and other living organisms. However, the seasonal rainfall enables a certain dilution of the pollutants to a level, which helps to prevent the death of living organism. The recorded values of SO_4^{2-} and Cl^- for lagoon were 130 - 160 mg/l and 1500 - 3000 mg/l respectively.

keywords: :Paper mill effluent, Valaichchenai lagoon, pollution, physical and chemical parameters.

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1 Introduction

The paper mill situated at Valaichchenai in the Eastern province of Sri Lanka provides most of the paper requirement in Sri Lanka. A general opinion among the public is that, the effluent from Valaichchenai paper mill pollutes the lagoon. A few reports are available regarding the presence of pollutants in the Valaichchenai lagoon, such as sulphide, sulphites, $CO_3,^{2-}$ fine fibres and colouring materials [8][9]. However all these studies were carried out 17 years back. In those days straw was used as a raw material but now waste paper is used. Pulping effluents occasionally have been associated with killing of aquatic and marine life, including fish. Some of these problems have been attributed to low DO concentrations in the watercourse, caused by high BOD loading. In other instances, they have been caused by constituents that are toxic to aquatic life, namely sulfides, mercaptans, resin acids, terpenes and metals from chemicals used in pulp processing, additives in paper making, or corrosion of equipment [1]-[7]. Therefore, a necessity arose to monitor the level of pollution in Valaichchenai lagoon.

2 Materials and methods:

The water samples for the analysis were collected from three different locations such as Valaichchenai lagoon (5-10 m away from paper machine outlet mixes with the lagoon), water from Vahaneri reservoir which is located 8 Km away from Valaichchenai factory (used as raw water for the Valaichchenai paper factory) and paper machine out let. Monthly three samples from each location were collected from September 96 to March 97, at a distance of about 10 m from the shore and a depth of two feet. Samples were collected and stored in polyethylene plastic bottles. It become necessary to preserve the collected samples in selected preservatives for effective testing as follows [9]

Table 1: Preservation of Smples

SAMPLE	CONTAINER	PRESERVATION
SET A:- For CO_3^{2-}, $HCO_3^- SO_4^{2-}$, Cl^-	Polyethylene plastic container (samples must be air tight and should not contact with air)	2.5 ml $CHCl_3$/500 ml
SET B:- All others except oxygen and trace elements	Glass bottles	5 ml of 4M H_2SO_4/500 ml
SET C:- Oxygen	Glass	on field
SET D:- Trace elements	Polyethylene plastic container(There should be no contact with air)	Con HNO_3 was added to pH=2.

Conductivity, salinity, turbidity and pH were measured by using portable meters (conductivity by Griffin model and Microprocessor LF 196 conductometer, salinity by microprocessor L F 196 salinometer, turbidity by japanees model Turbidometer and pH by Kent EIL 7020 model pH meter). Standard methods were used in the determination of chloride, sulphide, sulphate, fluoride, nitrate, phosphate, hardness, total suspended solids (SS), dissolved oxygen (DO), chemical oxygen demand (COD) and biological oxygen demand (BOD)[8][9]. The Table 2 gives the methods used to determine the availability of radicles and other factors in this study.

Table 2: Methods for to determine Redicles/Factors

Methods	Chemical factors/Parameters
Silvernitrate	Chloride
Iodometric titration	Sulphide
Gravimetric	Sulphate
Cadmium column reduction	Nitrate
Colorimetric	Phosphate
EDTA titrimetric	Hardness
Glass fibre filter	Total suspended solid
Winkler's	Dissolved oxygen and biological oxygen demand (BOD)
Potassium dichromate titration	Chemical oxygen demand (COD)
Atomic absorption spectrophotometer (VARIAN AA 1275)	Trace elements[8][9]

3 Results:

All the results are summarised in a tabulated form in Tables 3-7. Tables 3-5 show the physical and biological characters, chemical characters, and trace element concentrations of raw water, paper machine outlet and Valaichchenai lagoon respectively. A comparison of chemical and physical parameters of raw water, paper machine effluent and lagoon water with the Sri Lankan tolerance limits are tabulated in Tables 6 and 7. Pollution indicators, *Eristalis*, *Chironomous* and *Tubifix* were not observed, but MPN value exceeded the drinking water limit in all three different waters, raw, paper machine outlet and lagoon, (Table 3). Table 4 shows that the pH of raw and lagoon water was found to be slightly alkaline mean while the paper machine out let was slightly acidic. Concentration of suspended solid was very high for paper mill outlet(300-450 mg/l) and lagoon (150-235 mg/l) compared with Sri Lankan standard (150 mg/l), and it was within the range for raw water (60-80 mg/l). Turbidity of paper machine outlet and lagoon sample also show higher values (>500 mg/l), and this may be due to the presence of fine fibre, silt and clay.

The concentration of all measured trace elements in raw water was lower than the concentration of water in paper machine outlet and lagoon (Table 5). It clearly shows

Table 3: Physical and biological characters of raw water, water from paper machine outlet and Valaichchenai lagoon.

Parameter	Raw water from Vahaneri	Water from paper machine outlet	Water from Valaichchenai lagoon
Temperature (^{0}C)	28-32	32-36	28-32
Colour	colourless	light green slurry	light green
Unpleasant smell	no	no	no
Turbidity (mg/l)	20-30	>500	>500
Total dissolved solids (TDS) (mg/l)	1800-2000	3500-3800	4000-4500
Suspended solids (SS) (mg/l)	60-80	300-450	150-235
Most probable number (E.coli counting)	> 180	> 180	> 180
Pollution indicators (*Eristalis, Chironomous and Tubifix*)	not identified	not identified	not identified

Table 4: Chemical characters of raw water, water from paper machine outlet and water from lagoon.

Parameter	Raw water from Vahaneri	Water from paper machine outlet	Water from Valaichchenai lagoon
pH	7.5-7.6	6.1-6.5	7.5-7.6
Conductivity($\mu S/cm$)	300-400	480-1000	675-10000
Salinity(g/l)	0.0	0.3-0.6	3.0-15
Alkalinity (meq/l)(Methyl orange indicator)	0.2-1.8	0.4 - 0.824	0.6 -2.80
Hardness as CaCO3(mg/l)			
a. Total hardness as $CaCO_3$ (mg/l)	100-200	500-1400	200-850
b. Ca and Mg hardness as $CaCO_3$ (mg/l)	80-120	250-350	150-500
c. Ca as $CaCO_3$ (mg/l)	80-120	250-350	150-500
d. Mg as $CaCO_3$ (mg/l)	0.00	0.20-0.75	0.1-0.75
Chloride(mg/l)	150-200	100-150	1500-3000
Sulphide(mg/l)	0.001-0.0025	0.002-0.003	0.002-0.003
Sulphate(mg/l)	undetectable	50-90	130-160
Nitrate (mg/l)	0.3-0.6	0.5-1.0	1.0-1.5
Nitrite (mg/l)	0.003-0.005	0.005-0.008	0.007-0.009
Phosphate(mg/l)	0.03-0.6	0.08-1.3	0.09 -2.0
Dissolved oxygen(mg/l)	6.2-6.4	2.0-2.5	6.0-6.5
BOD_5(mg/l)	3.0-4.0	0.5-1.5	3.0-4.0
COD (mg/l)	25-30	48-55	50-70

Table 5: The concentration of trace elements in raw water, water from paper machine outlet and water from lagoon.

Element	Raw water (mg/l)	Water from paper machine outlet (mg/l)	Water from lagoon (mg/l)
Fe	0.1-0.4	1.0-3.0	0.5-5.0
Cu	0.02-0.04	0.06-0.1	0.005-0.1
Pb	0.03-0.07	0.01-0.025	0.05-0.3
Cd	0.002-0.005	0-0.005	0.003-0.005
Ni	0.006-0.02	0.05-0.2	0.04-0.25
Zn	0.01-0.03	0.1-0.15	0.02-0.2

Table 6: Maximum concentration of constituents (mg/l) in water for pulp and paper production and concentration of constituents of raw water from Vahaneri.

Parameter	Raw water (mg/l)	Acceptable level of raw water for pulp and paper manufacture (mg/l)
Iron	0.1-0.4	2.6
Chloride	150-200	200
Dissolved solids	1800-2000	1080
Suspended solids	60-80	-
Hardness	80-120	475

Table 7: The comparison of trace element concentrations (mg/l) in effluent of paper mills and in lagoon water with the SLS tolerance limit for "Effluents discharged into marine and coastal areas" [10].

Element	Paper machine effluent (mg/l)	Lagoon (mg/l)	Tolerance limit SLS (mg/l)
Fe	1-3	0.5-5	-
Cu	0.06-0.1	0.005-0.1	3
Pb	0.01-0.025	0.05-0.3	1
Cd	0.0-0.005	0.003-0.005	2
Ni	0.05-0.2	0.04-0.25	5
Zn	0.1-0.15	0.02-0.2	5

that processing contributing a reasonable increase of trace elements in the paper machine outlet, which may lead to the increase of the trace elements in the lagoon. Table 6 shows important physical and chemical parameters, which were used to determine the quality of Vahaneri raw water used for pulp making at Valaichchenai. It was found that all the parameters are within the acceptable level for the pulp and paper manufacture except the concentration of dissolved solids[3]. It is interesting to note that the concentration of trace elements of Valaichchenai paper mills effluent

and the lagoon were within the acceptable level for the survival of fish and prawn population (Table 7).

4 Discussion:

Based on the results of the analysis, it can be concluded that the parameters such as pH, Salinity, BOD, the anions S^{2-}, F^{-} , $NO_3{}^{-}$, $PO_4{}^{3-}$ and the trace elements were within the tolerance level in all the samples tested (Table 3). Dissolved oxygen concentration (6-6.5 mg/l) was in the tolerance range for lagoon and raw water. Lagoon sample showed high turbidity (>500 mg/l) and this condition may be a drawback for the survival of prawns and other living organisms. However, the seasonal rainfall enables a certain dilution of the pollutants to a level, which helps to prevent the death of entire organisms. The recorded values of $SO_4{}^{2-}$ and Cl^{-} for lagoon were 130 - 160 mg/l and 1500 - 3000 mg/l respectively. Unfortunately there is no record for tolerance level predicted by Sri Lankan Standards (SLS) or Central Environment Authority (CEA), to compare the concentration of $SO_4{}^{2-}$ and Cl^{-} for the existence of prawn and fish population.

5 Conclusions:

From the results of the analysis, based on the samples collected, it would be possible to draw the following conclusions.

The quality of the raw water from Vahaneri is within the acceptable level for the pulp and paper manufacture.

The chemical characters of lagoon such as pH, DO, BOD, COD and level of anions such as Cl^{-} , S^{2-}, F^{-}, $NO_2{}^{-}$ and $NO_3{}^{-}$ were virtually within the tolerance level in all the analysed lagoon samples tested according to SLS. But turbidity and suspended solids values exceeded the SLS limit. It may be a draw back and provide an unsuitable condition for the survival of prawns and other living organisms. However, when lagoon water is used for prawn/fish farming, sedimentation tanks are effective in reducing total suspended solids and turbidity due to suspended particles.

The results indicate that concentration of trace elements caused by the effluents discharged into the lagoon comply with the "Sri Lankan standards for effluents discharged into marine and coastal areas"[10]. The assessment of trace elements found in the lagoon indicated that water quality confirms to the level required for the purposes of fishery, prawn culture, washing and bathing. Perhaps, a question does exist about the accumulation of trace elements over long periods, even though the concentration of the trace elements found in the lagoon water is low at present and also by biomagnifying effects. This was not taken into account in this study.

The estimated level of all the parameters in the paper mills effluent comply with the "Sri Lankan standards for effluents discharged into marine and coastal areas",

except DO, BOD,suspended solid and turbidity. Adulteration of lagoon water by this effluent is an important matter on the long run, needs serious consideration. Aerating the effluent before discharging it into the lagoon can increase dissolved oxygen (DO) content of effluent. By passing the effluent through sedimentation tanks, total suspended solids and turbidity due to suspended particles in the effluent can be reduced. Therefore, the paper mills effluent appears to be harmless to discharge into the lagoon after passing it through sedimentation tanks and also by aerating the effluent [2].

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