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Physico-chemical characteristics of untreated and treated effluent of a paper industry

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ABSTRACT

Pollution is the introduction of contaminants into an environment, these contaminants cause instability, disorder, harm or discomfort to the physical systems and living organisms. Clean environment and water are precious and essential natural resources. Everyone has a duty to keep it clean and pollution free. It is now universally realized that any future developmental activity has to be viewed in light of its ultimate environmental impact. The tremendous increase in industrial activity during the last few decades and release of obnoxious industrial wastes in the environment, have been of considerable concern in recent years from the point of environmental pollution. The increase in pollution level is of great concern, in all over the world. The increasing pollution due to effluent generation from industries is also bringing a challenge to scientists. The menace of water-borne diseases and epidemics still threatens the well-being of population, particularly in under-developed and developing countries.

The effluent generates from the conventional paper mills generally contain more lignin compounds, Absorbable Organic Halide and Total Organic Chloride which even after treatment have much more BOD (bio-chemical oxygen demand), COD (chemical oxygen demand), suspended solids and other effluent parameters. A number of studies have already been carried out on the effluents of paper mills. During literature survey and discussions it was obtained that no detail study has been performed on the paper mill using cotton based raw material in India at the bank of river Narmada. The raw material used for manufacturing the paper not only polluting the water but also poisoning environment by cutting trees.

Key words: bleach, cotton-linter and cotton-comber, effluent, correlation.

INTRODUCTION

Human kind has entered a brand new relationship with the earth. The constant and increasing pressures were exerting threaten our planets ability to sustain life itself. In the last decade the problems of atmospheric change have been gravely advanced by pollution resulting from human activities. Human being are responsible for releasing huge quantity of pollutants in the environment the majority of these anthropogenic substances are waste products generated by industry and society consuming the manufactured goods. These environmental changes pose a real threat to the lives of people and wild life.

Water pollution causes approximately 14,000 deaths per day, all over the world mostly due to contamination of drinking water by untreated sewage in developing countries. Oil spills can cause skin irritations and rashes. Thus, the quality as well as the quantity of clean water supply is of vital significance for the welfare of mankind.

Industrial wastes are the waste products resulting from industrial processing operation. They include liquid, solid and gaseous waste. Liquid waste adversely affect the waste supply and sewage supply and sewage of towns and cities while a high amount of water is required for different industrial processes, only a small fraction of it is

incorporated in their products, the rest finds its way into the water course as waste product. This greatly contributes to the pollution problem.

The effluent generates from the conventional paper mills generally contain more lignin compounds, Absorbable Organic Halide and Total Organic Chloride which even after treatment have much more BOD (biological oxidation demand), COD (chemical oxygen demand), suspended solids and other effluent parameters. A number of studies have already been carried out on the effluents.

EXPERIMENTAL

The materials known today as "paper" actually can have a broad spectrum of printing and writing substrates, packaging and shipping containers, absorbent tissues and towels, molded products and numerous spatiality papers and other items. When one considers the widely differing physical configuration, strength and other properties demanded by the assortment of manufacturing goods, it is remarkable that it is largely derived from a single general type of renewable natural resource – the plant fibre. Even more remarkable are the vast majority of paper products that are made from an even more restricted subset of plant fibres – those derived from "cellulose".

Pulp

What are actually the plant fibres or cellulose? Well, to the pulp and paper maker generally it is an elongated or tubular, slender and actually very small cell obtained from plant parts; function primarily in mechanical support and in conduction. They can occur in isolated cells clusters or in large masses or tissues depending upon the plant type or part. Both woody and non-woody plants are used as a source of paper fibre[62]. The reduction of these raw materials to a form consisting essentially of individual fibres comprises the science of "pulping". The end product so obtained is known simply as "pulp".

Lignin

In most of the raw materials, the fibre wall is actually a composite material - a skeletal framework of "cellulose" together with a matrix substance of "hemicelluloses" and incrusting called "lignin". The two former components are polysaccharides and are hydrophilic while lignin is a polyphenolic largely hydrophobic molecule. Lignin is also the substance that helps cement fibres and other cells together in the plant body. Its removal is a major objective of chemical pulping. The present study deals with such a raw material having negligible lignin content. Therefore it is noteworthy to say the raw material itself as the "pulp".

Flat paper is made conventionally by depositing the "pulp" i.e. cellulose fibres from a dilute water suspension or slurry of pulp in a uniform mat or web of fibres onto a fine mesh screen through which the water has been drained, but the intermingled fibres remains stuck on it. The mesh is than pressed to remove excess water and finally dried to produce a coherent sheet with associated characteristic termed as "paper".

The conventional mill effluents generally come from washing the liquor of pulping and bleaching process of the paper mill. The major components of the paper mill effluent and three constituents are:

1. Biological characterization is also a relevant approach for the occurrence of mill effluent and has environmental impacts on aquatic organisms. Chemical characteristics of bleaching effluent and thus biological impact is given in table with reference to the conventional as well as currency paper making process. Sodium lignate as lignin in the form of sodium lignate breaks bond from the cellulose and dissolve in water.
2. Biological Oxygen Demand in the measure of Oxygen required for the biochemical degradation of organic material in effluent water. The bleach plant and pulp mill effluent of conventional mills contains residual lignin are the main cause for the low BOD, COD and TOCl of the effluents.
3. Similarly, the TOC (total organic carbon) is a measure of the carbon on all organic compounds both oxidized and non-oxidised in effluent, COD (chemical oxygen demand) is a measure of the oxygen consumed in the chemical oxidation of organic material in

water or effluent by various chemical oxidant. Other constituents like AOX (adsorbable organic halides), EOX (extractable organic halides), colour are the characteristics of the bleach effluents. The detail has been explained in the next chapter.

4. The washing of bleaching which generally contains chloro-lignin, adsorbable organic halides (AOX), total organic chloride (TOCl), which are very much hazardous and carcinogenic. Example of various chlorinated compounds found in bleaching.
5. Most of the chlorinated compounds separated in effluents from conventional chlorine bleaching. Levels of chlorinated compounds drop by a factor about 10 on ECF bleaching and there is a change in the relative proportions of some type of compounds. For example the total amount of chlorophenol decreased from greater than 100 g/ton of pulp on conventional bleaching effluent to 1- 10 g/ton on ECF effluent and below > 1 g/l on the TCF bleaching. The wide spectrum chloro-phenol formed in conventional chlorine bleaching effluent changes to give chlorinated by 6 chloro vanillion in ECF effluent. Few compounds, for example 1, 1 dichloro dimethylene do not appear to be markedly affected by the change from conventional to ECF bleaching. Only trace amount of few polychlorinated (> 2 chlorine atom) compounds are formed in ECF effluents. The level of chloroform drops from > 300 g/ton of pulp on conventional bleaching to 10 g/ton on ECF effluent. As stated in the introduction, individual compounds have not been observed in the TCF effluents.

RESULTS AND DISCUSSION

The pH and temperature of the water were normal i.e. ranges from 7.2 to 8.4 and 20°C-30°C. The Calcium hardness of the receiver water was found to be 40-110 mg/l which is slightly in higher side which may be due to the nature of the soil and mineral characteristics of the nearby locality. The other properties i.e. alkalinity, TDS, TSS, COD, BOD, SO_4^{--}, Cl^-, PO_4^{3-} etc. were in the normal range viz 98 - 250 mg/L, 66 - 216 mg/L, 14 - 28 mg/L, 20 - 80 mg/L, 5 - 11 mg/L, 1.6 - 3.0 mg/L, 14 - 26 mg/L, 0.3 - 7.6 mg/L respectively and were even better to the raw water characteristics of other rivers in general.

Table 1: Physico-chemical characteristics of Narmada River water, Hoshangabad (2008)

Parameter	Jan 08	Apr 08	Jul 08	Oct 08
Temp.	22	30	27	25
pH	7.23	7.54	7.5	7.25
Ca Hardness	70	110	82	84
Mg Hardness	58	62	36	64
Total hardness	128	172	118	148
Alkalinity	140	250	150	146
TDS	100	126	216	128
TSS	18	17	28	12
COD	64	80	20	75
BOD	7	10	11	9
Conductivity (mS/cm)	0.26	0.22	0.37	0.28
SO_4	2.1	1.6	1.6	3.0
Cl^-	24	24	26	20
PO_4^{3-}	4.5	6.7	7.6	2.5

Table 2: Physico-chemical characteristics of untreated effluent from paper machine (2008)

Parameter	Jan 08	Apr 08	Jul 08	Oct 08
Temp.	20	43	37	22
pH	8.0	8.0	8.0	8.0
Ca Hardness	117	105	118	89
Mg Hardness	77	96	79	97
Total hardness	194	201	197	186
Alkalinity	340	250	330	310
TDS	212	200	240	235
TSS	160	160	178	160
COD	240	240	300	260
BOD	44	46	44	52
Conductivity (mS/cm)	0.44	0.34	0.39	0.34
SO_4^{2-}	3	2.7	2.2	2.1
Cl^-	30	24	28	31
PO_4^{3-}	5.9	4.5	3.3	2.6

Table 3: Physico-chemical characteristics of treated effluent from ETP (year 2008)

Parameter	Jan 08	Apr 08	Jul 08	Oct 08
Temp.	20	43	37	22
pH	7.7	7.5	7.5	7.8
Ca Hardness	105	111	99	107
Mg Harness	73	80	69	75
Total hardness	178	191	168	182
Alkalinity	217	220	230	215
TDS	196	180	210	198
TSS	58	56	54	52
COD	30	30	30	30
BOD	8.0	10	9	10
Conductivity (mS/cm)	0.30	0.28	0.25	0.28
SO_4^{2-}	13.8	14.6	14.2	13.4
Cl^-	23	26	27	29
PO_4^{3-}	2.6	2.9	1.8	3.1

Physico chemical characteristics of untreated white water from the paper machine shows pH 8.0-8.5 with 162-208 mg/L of total hardness and 0.28-0.44 mS/cm of conductivity. The value of alkalinity, total dissolved and total suspended solids were found to be in the range of 186-370 mg/L, 190-250 mg/L and 147-358 mg/L respectively. COD and BOD were found to be 240-300 mg/L and 36-60 mg/L respectively. The concentration of chloride, sulphate and phosphate were in the range of 17-32 mg/L, 1.6-3.0 mg/L and 2.2-6.9 mg/L respectively.

The effluent water is mainly the washing of paper machine back water. Hence the effluent composition is mainly the unbounded and washed fibres of paper mill and some of the unreacted chemicals. The colour of the effluent is slightly turbid which is due to the suspended fibres. The TSS is more than the prescribed limit of the pollution control board. This is due to the more fibre present in the effluent. Similarly more BOD and COD is due to some the degenerated cellulosic fibre and may also be due to some chemical present which are oxidized by the dissolved oxygen. All the other parameters are in the normal range. It reflects from the table that the BOD, COD of the sample are marginally higher.

The temperature, pH, hardness and alkalinity were found to be in the normal range viz. 18-35 °C, 7.0-7.8, 168-182 mg/L, 207-235 mg/L respectively. The total dissolved solids, total suspended solid, BOD and COD were ranges from 180-224 mg/L, 44-60 mg/L, 9-44 mg/L and 30-40 mg/L respectively. TDS, TSS, BOD and COD were well within the tolerance limit of the standard prescribed by the indian standards. The reduction of the concentration show that the effluent treatment plant of the industry runs effectively. But the low BOD, COD concentration ensure of untreated effluent is mainly due to the high cellulose and negligible lignin content. Although the cellulose is an organic compound, but due to the higher molecular weight of the cellulose, it is difficult to degrade by the oxygen present in the water. In the other hand in conventional paper mill effluent along with cellulose the residual lignin is present, which is a macromolecule. The bond in lignin already loosens during the treatment of caustic in the pulping process. A huge quantity of oxygen is required to decompose the lignin molecule to simpler unit. This results into more BOD and COD content in conventional paper mill effluent. Other parameters sulphate, chloride, phosphate and conductivity were found to be 120 to 158 mg/L, 22 to 30 mg/L, 1.8 to 3.1 mg/L and 0.22 to 0.33 mS/cm respectively and were in normal range.

Table 4: Co-relation matrix for physico-chemical characteristics of Narmada river water at intake point in paper mill

	TEMP	PH	Ca Hardness	Mg Hardness	Total Hardness	Alkalinity	TDS	TSS	COD	BOD	Conductivity
TEMP	1										
PH	-0.03	1									
Ca Hardness	0.585	-0.631	1								
Mg Hardness	-0.198	0.345	-0.194	1							
Total Hardness	0.451	-0.306	0.736	0.503	1						
Alkalinity	0.716	-0.387	0.921	-0.086	0.753	1					
TDS	0.632	0.053	0.106	-0.311	-0.027	0.036	1				
TSS	0.358	-0.021	0.106	-0.49	-0.209	0.021	0.733	1			
COD	0.014	-0.258	0.389	0.463	0.667	0.481	-0.572	-0.762	1		
BOD	0.544	-0.088	0.344	-0.685	-0.081	0.298	0.592	0.459	-0.188	1	
Conductivity	0.269	0.108	-0.296	-0.242	-0.362	-0.394	0.843	0.573	-0.737	0.232	1
Sulphate	-0.385	-0.441	0.031	-0.033	0.041	-0.198	-0.16	-0.419	0.411	0.188	-0.137
Chloride	0.421	-0.533	0.597	-0.419	0.293	0.462	0.483	0.695	-0.113	0.561	0.115
Phospate	0.077	-0.101	0.37	-0.368	0.008	0.316	0.033	0.632	-0.357	0.196	-0.207

Table 5: Co-relation matrix for physico-chemical characteristics of untreated effluent from paper machine

	TEMP	PH	Ca Hardness	Mg Hardness	Total Hardness	Alkalinity	TDS	TSS	COD	BOD	Conductivity
PH	0.364	1									
Ca Hardness	0.256	-0.228	1								
Mg Hardness	0.379	-0.22	-0.148	1							
Total Hardness	0.518	-0.297	0.56	0.736	1						
Alkalinity	-0.778	-0.37	0.115	-0.722	-0.551	1					
TDS	-0.193	-0.594	0.167	0.42	0.444	0.154	1				
TSS	-0.211	-0.27	-0.067	0.133	0.053	-0.006	0.476	1			
COD	-0.074	-0.404	0.234	-0.163	0.004	0.46	0.676	0.141	1		
BOD	0.038	0.113	-0.192	0.171	0.017	-0.08	0.077	-0.555	0.212	1	
Conductivity	-0.377	-0.489	0.328	-0.056	0.156	0.305	0.341	0.692	-0.009	-0.827	1
Sulphate	-0.266	-0.223	0.257	-0.502	-0.259	0.42	-0.576	-0.455	-0.306	-0.111	0.078
Chloride	0.114	0.417	0.074	0.02	0.09	-0.039	-0.174	-0.826	-0.099	0.593	-0.595
Phospate	-0.285	0.035	0.176	-0.7	-0.47	0.472	-0.602	-0.484	-0.139	0.219	-0.231

Table 6: Co-relation matrix for physico-chemical characteristics of treated effluent from ETP

	TEMP	PH	Ca Hardness	Mg Hardness	Total Hardness	Alkalinity	TDS	TSS	COD	BOD	Conductivity
TEMP	1										
PH	-0.401	1									
Ca Hardness	0.554	-0.585	1								
Mg Hardness	-0.146	0.535	-0.155	1							
Total Hardness	0.42	-0.223	0.82	0.438	1						
Alkalinity	0.557	-0.239	0.263	-0.038	0.218	1					
TDS	0.12	-0.237	0.055	-0.84	-0.436	-0.218	1				
TSS	-0.552	0.59	-0.669	0.712	-0.196	-0.129	-0.605	1			
COD	-0.255	-0.026	-0.01	0.427	0.238	0.044	-0.236	0.461	1		
BOD	0.204	-0.124	0.406	0.338	0.565	0.176	-0.068	0.032	0.827	1	
Conductivity	-0.079	-0.179	0.077	-0.349	-0.132	-0.201	-0.005	-0.338	-0.826	-0.845	1
Sulphate	0.239	-0.315	0.056	-0.514	-0.247	-0.527	0.616	-0.435	-0.471	-0.338	0.356
Chloride	0.345	0.377	0.135	0.411	0.361	0.504	-0.206	0.017	0.295	0.575	-0.599
Phospate	-0.451	0.644	-0.179	0.832	0.319	-0.481	-0.594	0.548	0.272	0.191	-0.126

Table 7: Co-relation matrix for physico-chemical characteristics of Nala water from the mill (year 2007-2008)

	TEMP	PH	Ca Hardness	Mg Hardness	Total Hardness	Alkalinity	TDS	TSS	COD	BOD	Conductivity
TEMP	1										
PH	0.167	1									
Ca Hardness	-0.492	-0.594	1								
Mg Hardness	-0.223	-0.363	0.296	1							
Total Hardness	-0.451	-0.6	0.824	0.785	1						
Alkalinity	-0.236	0.322	0.416	-0.258	-0.423	1					
TDS	-0.603	-0.599	0.656	0.524	0.736	-0.56	1				
TSS	-0.066	0.12	-0.4	0.254	-0.109	0.468	-0.23	1			
COD	0.216	0.087	-0.256	0.399	0.071	0.48	-0.477	0.653	1		
BOD	0.418	0.02	-0.31	0.348	0.005	0.38	-0.513	0.49	0.798	1	
Conductivity	0.513	-0.169	-0.569	0.242	-0.225	0.182	-0.291	0.208	0.477	0.552	1
Sulphate	-0.127	0.56	-0.64	-0.258	-0.568	0.794	-0.483	0.147	0.21	0.149	0.333
Chloride	0.044	-0.085	0.276	0.461	0.453	-0.753	0.481	0.107	-0.069	-0.258	-0.265
Phospate	-0.149	-0.04	0.283	-0.551	-0.143	-0.002	0.008	-0.652	-0.398	-0.648	-0.254

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