NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581-4230
VOLUME 3, ISSUE 11, Nov. -2017

PERFORMANCE STUDY OF COAGULATION & BALLAST FLOCCULATION FOR RECYCLE BASED KRAFT PAPER MILL

MRS. SUSHMA SANGRAM KUMBHAR
Research Scholar, Environmental Science and Technology, Faculty of Engineering and Technology, Shivaji University, Kolhapur, Maharashtra India

MR. S. M. BHOSALE
Coordinator, Environmental Science and Technology, Faculty of Engineering and Technology, Shivaji University, Kolhapur, Maharashtra India

ABSTRACT:

The pulp and paper industry is one of India's oldest and core industrial sector. The socio-economic importance of paper has its own value to the countries development as it is directly related to the industrial and economic growth of the country. Although paper has many uses, its most important contribution to modern civilization is its use as a medium to record knowledge.

Paper manufacturing is a highly capital, energy and water intensive industry. It is also a highly polluting process and requires substantial investments in pollution control equipment. Present research work describes a study of Coagulation & Ballast Flocculation for Recycle based Kraft paper mill.

INTRODUCTION:

Today there are more than 600 pulp and paper mills in the country, nearly 6.2 million tons of paper, paper boards and news print is produced against an operating installed capacity of nearly 8.5 million tons (Shukla et al., 2008). According to recent studies, the Indian paper industry is poised to grow from 7.2 million tones in 2005-06 to 13.95 million tones in 2015- 2016. The demand for paper in India is witnessing a healthy growth of 7 % to 8% compared to 5% in the past, and there is huge potential for more (Prinen et al., 2008). The paper is manufactured from three major kinds of raw materials, viz. wood, agricultural residues and recycled fibers. The total wood used in paper manufacturing is 5.8 million ton per year in India (Panwar et al., 2008). Fast depletion of natural forest in the country has resulted in acute shortage of forest-based raw material for the paper industry. Efforts were made for the plantation of fast growing trees like eucalyptus. But the supply of wood is not sufficient to meet the growing demand of paper industry. Because of this short supply of eucalyptus and bamboo, the agricultural residues have gained importance. Wheat straw, rice straw and other grasses are being used since long but the bagasse, which is a waste, obtained after extraction of sugar juice is gaining importance day to day. Bagasse and wheat straw is used in Northern India. Wheat straw is not available in plenty because it is a regular cattle feed and rice straw is not a suitable raw material for large and medium paper mills especially for the production of good quality papers. Bagasse is a suitable raw material for most grade of paper and its availability is increasing day by day as more and more sugar mills improving their boiler efficiency to spare more and more bagasse for paper industry.

LITERATURE REVIEW:

Hanif et al.,(2006) adopted Cassia fistula for physoco-chemical treatment of textile wastewater as coagulation and TDS removal. The methodology was to find optimum pH and optimum dose by using the Jar test apparatus. They observed that, the optimum pH for both units viz. Dyeing unit and finishing unit, was 6. By addition of sulfuric acid the alkaline wastewater was brought to the optimum pH. Dosing was varied from 250 mg/l to 1500 mg/L and TDS removal achieved was from 15% to 88% and turbidity removal from 10% to 60%.

Aziz et al.,(2007) studied the effect of Alum, Ferric chloride, Ferrous sulfate, Ferric sulfate for removal of color from landfill leachate. The study shows that ferric chloride is the most efficient coagulant as compared to the others. They studied the effect of coagulant at different pH like 4, 6 and 12. At lower pH 4 optimum doses of all coagulants was observed to be more efficient than at other pH. For Alum the optimum dose was 2200 mg/L with color removal efficiency of 82%. In case of Ferric chloride it 800 mg/L with color removal of 94%.

Zonoozi et al., (2008) studied the efficiency of PAC and Alum for removal of Acid red 398 dye from an aqueous solution using the Jar test apparatus. The study was carried using the Jar test apparatus. In case of PAC the best removal efficiency was nearly about 80% at the dose of 100 mg/L to 120 mg/L, whereas for Alum it was 60% at the dose of 140 mg/L to 160 mg/L. They also studied the effect of coagulation aid Bentonite, which resulted in an enhanced performance in color removal, and this was increased by 15% for alum and 9% when used with PAC.

Guendy (2010) the effect of coagulants for various dosage and pH for color removal was examined using the Jar test apparatus. The effect of Ferric chloride was compared with the results of Alum. The effective dose for both coagulants was 50 mg/L in the pH range of 4-6. The efficiency observed at the above condition was 90%.

Aygun and Yilmaz,(2010) studied the effect of coagulation with Ferric chloride by providing coagulant aid as polyelectrolytes and clay minerals like montmorillonite and bentonite for treatment of Detergent wastewater. Optimum condition ferric chloride was obtained at pH 11 with dosing of 2000 mg/L in which COD removal achieved was 71%. Using clay minerals at the dose of 500 mg/L with ferric chloride provided 84% of COD removal and removal efficiency using polyelectrolyte was 87%.

Parmar et al.,(2011) studied the use of Ferrous sulfate and Alum as a coagulant in treatment of Dairy industry wastewater. They studied the use of coagulants in the Jar test apparatus in the Jars of 1000 ml capacity. The study was conducted at the optimum pH of 4.5 with the varying dosage from 25 mg/L to 500 mg/L Appreciable COD removal was observed at optimum pH of 4.5 with dose 100 mg/L with 99% of turbidity removal at the same dose and pH .

Islam et al.,(2011) studied the efficiency of coagulants combination for treatment of tannery wastewater. They studied the effect of Alum, Ferric chloride and Lime and their combination. The results for alum and ferric chloride as an individual coagulants was obtained to be satisfactory with color removal efficiency of 85% and 82% respectively than their combination with other coagulants, at pH 6.83 and 5.73, the dosing was 70 mg/L. In case of COD removal, alum and ferric chloride achieved the removal efficiency of 80% and 79% respectively.

Literature review defines that Coagulation, ballast Flocculation system has potential application in treating wastewater from recycle based Kraft paper mill. Objectives were set to study the wastewater characteristics of Kraft paper industry. To carry out experiments on bench scale with Jar test.To perform coagulation and ballast flocculation for removal efficiency of suspended solids, color, chemical oxygen demand. To determine optimal dose for coagulant, ballast flocculation for removal efficiency of suspended solid, color, chemical oxygen demand. To verify the effect of reuse micro sand on removal efficiency of suspended solid, color, chemical oxygen demand.

COAGULATION –FLOCCULATION AND BALLAST FLOCCULATION:

In wastewater treatment, coagulation and flocculation are employed to separate suspended solids from water. Although the terms coagulation and flocculation are often used the single term "flocculation" is used to describe both; they are, in fact, two distinct processes. Finely dispersed solids (colloids) suspended in wastewaters are stabilized by negative electric charges on their surfaces, causing them to repel each other. Since this prevents these charged particles from colliding to form larger masses, called flocks, they do not settle. For removal of colloidal particles from suspension, chemical coagulation and flocculation are required. These processes, usually done in sequence, are a combination of physical and chemical procedures. Chemicals are mixed with wastewater to promote the aggregation of the suspended solids in to particles large enough to settle or be removed. Coagulation is the destabilization of colloids by neutralizing the forces that keep them apart. Cationic coagulants provide positive electric charges to reduce the negative charge (zeta potential) of the colloids. As a result, the particles collide to form larger particles (flocs).Rapid mixing is required to disperse the coagulant throughout the liquid. Ballasted flocculation, also known as high rate clarification, is a physical-chemical treatment process that uses continuously recycled media and a variety of additives to improve the settling properties of suspended solids through improved floc bridging. The objective of this process is to form micro floc particles with a specific gravity of greater than two. Faster floc formation and decreased particle settling time allow clarification to occur up to ten times faster than with conventional clarification, allowing treatment of flows at a significantly higher rate than allowed by traditional unit processes. Ballasted flocculation units function through the addition of a coagulant, such as ferric sulphate, an anionic polymer, and a ballast material such as micro sand, a micro carrier, or chemically enhanced sludge. When coupled with chemical addition, this ballast material has been shown to be effective in reducing coagulation sedimentation time.

ADVANTAGES OF COAGULATION- FLOCCULATION AND BALLAST FLOCCULATION:

i. Coagulation–flocculation is one of the most important physicochemical treatment steps in industrial wastewater treatment to reduce the suspended and colloidal materials.
ii. It reduces the organic matters which contributes to the BOD and COD content of the wastewater

iii. Addition of coagulants involves destabilization of the particulate matters present in the wastewater, followed by particle collision and floc formation which results in the sedimentation.
iv. Coagulation and flocculation can be used effectively for color removal.
v. Large sand particle surface area serves as a "seed" for floc formation
vi. Microsand and polymer produce a large, stable floc
vii. Microsand (specific gravity 2.65) serves as ballast for the formation of high-density floc
viii. Enhance coagulation allows for variable process chemistry.
ix. The reduced surface area of the clarifiers minimizes short-circuiting and flow patterns caused by wind and freezing
x. Systems using ballasted flocculation can treat a wider range of flows without reducing removal efficiencies.
xi. Enhanced primary clarification.

MATERIAL AND METHODOLOGY:

MATERIAL:

WASTEWATER SAMPLE:

The sample was collected form Biltube Industries Ltd., Warnanagar, Tal. Panhala, Dist. Kolhapur The nature of sampling done is grab sampling. Grab Sampling means all of the test materials are collected at one time.

ALUM:

The aluminum sulphate, $Al_2(SO_4)_3.18H_2O$ was Chemicals in the form of white crystalline solid. The molecular weight of the aluminum sulphate is 666.43 g/mol. was purchase from Eagle Scientific Company Gangavesh Kolhapur in the solid form. For the experiment it is used in powder form with dosed in grams.

FERRIC CHLORIDE (FECL3):

Ferric chloride, $Fe_2Cl_3.6H_2O$ was purchased from Eagle Scientific Company Gangavesh Kolhapur. The molecular weight of the ferric chloride is 270.30 g/mol. The powder form is used at the time of experiment.

FLOCCULENT IND-FLOC 441:

Ind-Floc 441 is a high molecular weight polyacrylamide. It was appeared white granular powder, with bulk density 0.6-0.8 gm/ml. This flocculent is anionic type .It was purchased from Ion Exchange India Ltd. sales office: Pune Road, Kasarwadi, Pune-India.

BALLASTING AGENT (BA):

The micro sand of 90 to 150 micron diameter was used for the experiments. It was collected from Patil Enviro Engineers, Hatkanangale, Kolhapur Specific gravity of micro sand is more than 2.6 and having density of 2700 kg/m3.

METHODOLOGY:

i. The analysis of parameter namely suspended solids, color, chemical oxygen demand and treated effluent will be carried out as per Standard Methods for Examination of Water & wastewater prepared and published by American Public Health Association (APHA) for raw vegetable tannery wastewater.
ii. Jar test apparatus will be used to determine optimal dose of coagulant and ballast flocculent for Color, SS, and COD removal.
iii. Experiment will be conducted using reuse micro sand for ballast flocculation.

JAR TEST EXPERIMENT:

Jar testing is a common laboratory procedure used to determine the optimum operating conditions for water or wastewater treatment. Jar test simulates the coagulation and flocculation processes where optimum conditions are determined empirically rather than theoretically. The values that are obtained through the experiment are correlated and adjusted in order to account for the actual treatment system. The main variables coagulant dosage and pH were investigated in this research.

The jar testing process can be summarized as

1. Six beakers are used for the experiment.
2. Measure the equal volume of sample into each of beakers.
3. Place the beakers such that the paddles are in center.
4. Record the sample temperature, pH turbidity, COD and color at start of test.
5. Experiments will be conducted for determining optimum pH and optimum dose of coagulant and flocculent.
6. Experiment will be conducted using 90- 150 micrometer size microsand for ballast flocculation with maximum removal and optimum dose of coagulant and flocculent.
7. Experiment will be conducted using reuse of 90-150 micrometer size microsand for ballast flocculation with maximum removal and optimum dose of coagulant and flocculent.
8. After the final settling withdraw adequate sample volume of supernatant from Jar .

9. Record the Supernatant liquid temperature, pH turbidity, COD and color

ANALYTICAL METHODS:

All of the quality parameters that applied in the study such as total suspended solids (TSS), chemical oxygen demand (COD), color and pH were analyzed according to the procedures described in Standard Method for the Examination of Water and Wastewater (APHA, 2002).

Table 1: Parameters of analysis and their method.

Sr. No.	Parameter of analysis	Method
1	pH	Electronic pH meter
2	Colour	Spectrophotometer
3	Total suspended solids	Oven Drying Method
4	COD	COD Reflux Method

RESULTS AND DISCUSSIONS:

INTRODUCTION:

To Study the Efficacy of Coagulation and Ballast Flocculation for recycle based Kraft paper mill Wastewater. Aluminum Sulphate, Ferric chloride , as a Coagulant along with IND-FLOC 441 as a Flocculent were used to find removal efficiency of TSS, Color and COD. The Ballast Flocculation was done by using micro sand, Aluminum Sulphate along with IND-FLOC 441 and also the effect of reused micro sand on removal efficiency for TSS, Color and COD was studied.

CHARACTERIZATION OF WASTEWATER:

In order to know the variation in pollution strength of combined wastewater, the wastewater sample from collection tank & final treated water tank were collected and analyzed. The industrial wastewater characteristics of Biltube Industries Ltd. are given in Table 4.1.

Table 2 : Wastewater Characteristics

Parameter	Standards	Untreated Effluent	Treated Effluent
pH	6.5 to 8.0	5.5	7.16
Colour	Clear	Brown	Slight Brown
Temperature ^oC	-	32	33
COD (mg/L)	250	10500	800
BOD_5 (mg/L)	100	6500	450
TSS (mg/L)	100	2200	750
TDS (mg/L)	2100	6800	5000
Chlorides (mg/L)	600	700	300
Sulphates (mg/L)	1000	1810	500
EC (μmhos /cm)	-	7525	1050

The characterized effluent is acidic in pH, because processes like addition of alum and due to recycling practices of wastewater; the nature of the waste is acidic. High COD value is due to the addition of chemical and recycling practices of wastewater. The recycling practices and addition of lime in primary treatment increases concentration which contributes to the high alkalinity of the waste. Color is an important character of Kraft paper waste water; it is due to presence of lignins in it. TSS is due to the fine fiber of pulp. Coagulation-flocculation process was conducted for the treatment of the Kraft paper wastewater. Jar tests were carried out in order to establish a practical understanding of coagulation performance and to find optimum pH, coagulant dosage and color removal efficiency.

JAR TEST RESULT BY USING CHEMICAL COAGULANT ALUM:

Alum is both a specific chemical compound and a class of chemical compounds. The specific compound is the hydrated potassium aluminium sulfate (potassium alum) with the formula $KAl(SO_4)_2 \cdot 12H_2O$. The wider class of compounds known as alums have the related empirical formula, $Al_2(SO_4)_2 \cdot 14H_2O$.

Fig 1: Chemical Coagulant - Alum

CHEMISTRY OF ALUM COAGULATION:

When alum is added to water it undergoes the reaction below. The alum reacts with bicarbonate to form aluminum hydroxide, a precipitate. The coagulation reactions are as follows:

$Al_2(SO_4)_3 + 3Ca(HCO_3)_2 \rightarrow 2Al(OH)_3 + 3CaSO_4 + 6CO_2$

Precipitate salt gas

$Al_2(SO_4)_3 + 3Na_2CO_3 + 3H_2O \rightarrow 2Al(OH)_3 + 3Na_2SO_4 + 3CO_2$

$Al_2(SO_4)_3 + 6NaOH \rightarrow 2Al(OH)_3 + 3Na_2SO_4$

$Al_2(SO_4)_3 + 6H_2O \rightarrow 2Al(OH)_3\uparrow + 3H_2SO_4$

(A. Koohestanian et al., 2008)

EFFECT OF PH : The pH is a key parameter in the coagulation process. The optimum value of pH depends on the properties of the wastewater treated, type of the coagulant used and its concentration. (Farajnezhad et.al) The pH affects not only the surface charge of coagulants, but also the stabilization of the suspension; it is the most important variable in the coagulation process for water treatment. A suitable pH will help to neutralize the negative charge of colloidal particles and to form linkages between colloid particles, thus effectively helping with floc formation and reaching the expected settlement.(Nasir et.al) In this experiments were performed to assess COD, TSS and Colour removal as well as coagulation-flocculation at various pH values. The optimum pH obtained was 6 at a constant alum dose of 200mg/L. At a pH of 6 the optimum percent removal for TSS, COD and Colour reduction were 64.5%, 58%, and 41.5 % respectively. In general, decreasing the pH from the alkaline levels to near neutral levels has a strong positive effect on removal of TSS, COD and Colour.

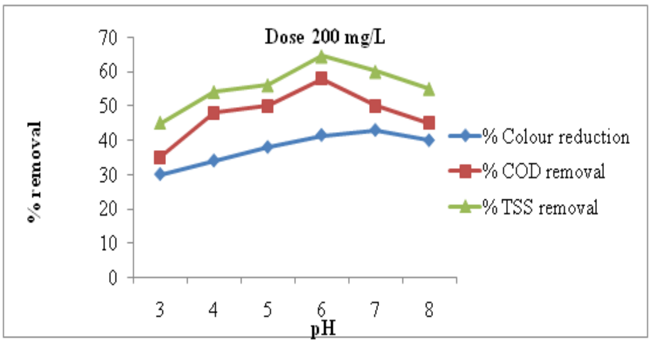

Fig 2: Graph indicates percent removal of TSS, COD and Colour reduction Vs pH.

EFFECT OF ALUM DOSAGE: Dosage was the most important parameter that was considered to determine the optimum condition for the performance of coagulation and flocculation. Each type of coagulant has its own characteristic optimum dosage range. Basically, insufficient dosage or overdosing will result in poor performance in flocculation. Therefore, it was crucial to determine the optimum dosage in order to minimize the dosing cost and obtain the optimum performance in treatment. (Nasir et.al) In this experiments were performed to assess COD, TSS and Colour removal as well as coagulation-flocculation at various alum dose(mg/L). The optimum dose obtained was 200mg/L at a constant pH-6. At a Alum dose 200 mg/L, the optimum percent removal for TSS, COD and Colour reduction were68%, 61% and 43%respectively.

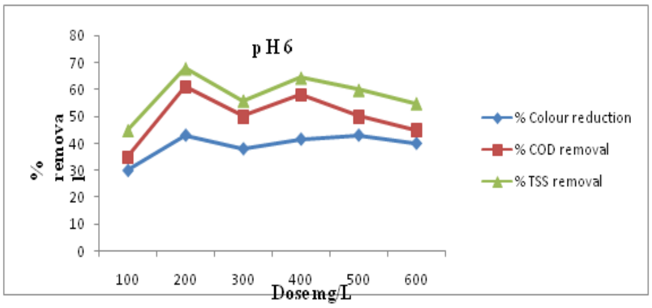

Fig 3: Graph indicates percent removal of TSS, COD and Colour reduction Vs Alum Dose mg/L.

JAR TEST RESULT BY USING CHEMICAL COAGULANT FERRIC CHLORIDE: Ferric chloride is the iron salt used most commonly in precipitation application. The addition of ferric chloride to a wastewater produces the hydrolysis of the ferric chloride with the consequent formation of insoluble ferric hydroxide. The insoluble ferric hydroxide forms a floc responsible for colloid removal. If the wastewater is not buffered the PH is decrease which will prevent the reaction from proceeding any further. In the presence of calcium or magnesium bicarbonate ferric chloride forms ferric hydroxide, which precipitates as before forming a sweeping floc responsible for colloid removal.

$2FeCl_3 + 3\,Ca(HCO_3)_2$ ------ $2\,Fe(OH)_3 + 3CaCl_2 + 6CO_2$

Fig 4: Chemical Coagulant, Ferric Chloride

EFFECT OF PH: In this experiments were performed to assess COD, TSS and Colour removal as well as coagulation-flocculation at various pH values. The optimum pH obtained was 4 at a constant Ferric Chloride dose (mg/L).At a pH 4, the optimum percent removal for TSS, COD and Colour reduction were53%, 45% and 35% respectively.

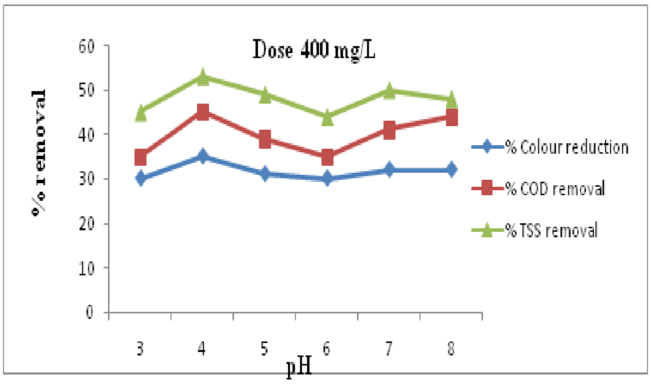

Fig 5: Graph indicates percent removal of TSS, COD and Colour reduction Vs pH.

EFFECT OF FERRIC CHLORIDE DOSAGE: In this experiments were performed to assess COD, TSS and colour removal as well as coagulation-flocculation at various Ferric Chloride dose(mg/L). The optimum dose obtained was 400mg/L at a constant pH-4. At a dose 400 mg/L, the optimum percent removal for TSS, COD and Colour reduction were 64%, 58% and 41% respectively. As the concentration of suspended solids in raw wastewater was considerably high, the destabilizing of colloidal particles occurs due to the adsorption of strongly charge partially hydrolysed metallic ions. Continued adsorption will result in charge reversal and restabilization of the suspension which does occur at higher coagulant dosages. (Aziz et.al)

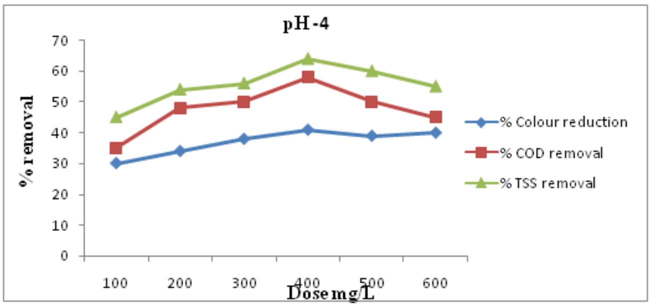

Fig 6: Graph indicates percent removal of TSS, COD and Colour reduction Vs Ferric Chloride Dose mg/L.

JAR TEST RESULT BY USING CA-90: In this experiments were performed to assess COD, TSS and Colour removal as well as coagulation-flocculation at various dose(mg/L). The optimum dose obtained was 2mg/L at a constant pH-6 & Alum dose 200 mg/L. At a dose2 mg/L, the optimum percent removal for TSS, COD and Colour reduction were 61%, 56% and 43% respectively. Alum was coupled with CA-90. Flocculent doses were increased from 0.5 to 3 mg/L with the fix amount of alum (200 mg/L). The initial pH of wastewater was adjusted to pH 6. The removal of TSS, COD and Colour efficiencies were calculated from the TSS, COD, and Colour initial concentration in raw waste water and final concentration in the supernatant. It can be seen that increasing flocculent doses does not always improve the removal rates. The use of flocculent lowers the coagulant doses needed to obtain a satisfactory reduction in COD.

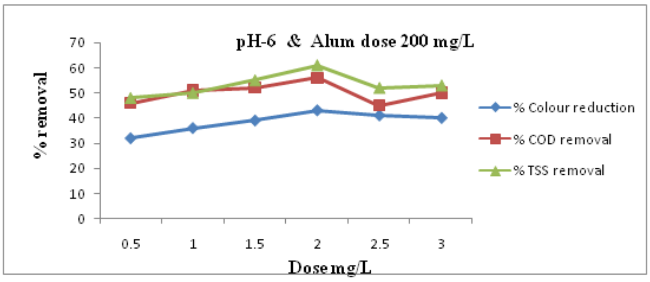

Fig 7: Graph indicates percent removal of TSS, COD and Colour reduction Vs CA-90 Dose mg/L.

JAR TEST RESULT BY USING INDFLOC-441: Indfloc 441 is high efficiency anionic polyelectrolyte specially design for solid- liquid separation process. One of the important features of Indfloc - 441 is that it is effective at low dosages. In this experiments were performed to assess COD, TSS and Colour removal as well as coagulation-flocculation at various dose (mg/L).The optimum dose obtained was 1 mg/lit for an constant pH-6& Alum dose 200 mg/L. At a dose of 1mg/L, the optimum percent removal for TSS, COD and Colour reduction were 65%,62% and 66% respectively.

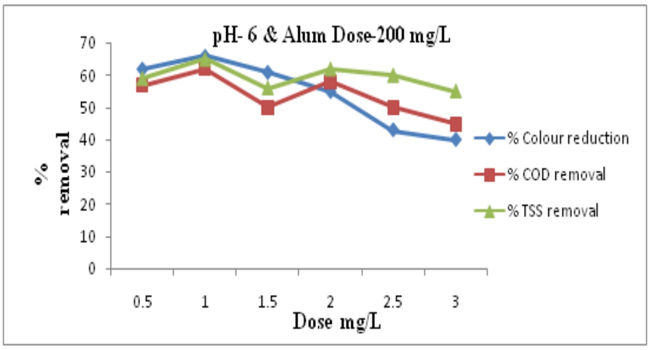

Fig 8: Graph indicates percent removal of TSS, COD and Colour reduction Vs Indfloc-441Dose mg/L.

JAR TEST RESULT BY USING BALLAST SAND: In this experiments were performed to assess COD, TSS and Colour removal as well as coagulation-flocculation at various dose(mg/L). The optimum dose obtained was 600mg/L at a constant pH-6, Alum dose 200 mg/L & Indfloc 441-1 mg/L. At a dose of 600mg/L, the optimum percent removal for TSS, COD and Colour reduction were 80%, 65% and 75%respectively.

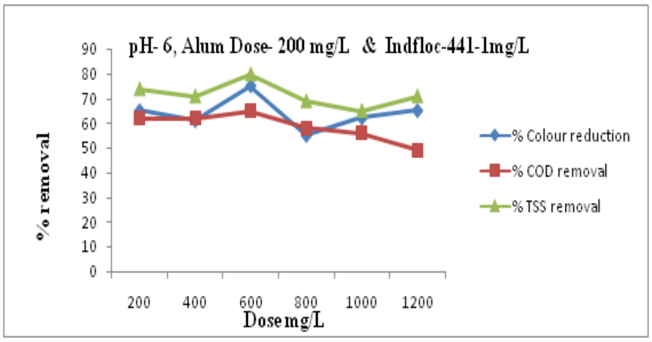

Fig 9: Graph indicates percent removal of TSS, COD and Colour reduction Vs Ballast sand Dose mg/L.

JAR TEST RESULT BY USING RECYCLED BALLAST SAND: In this experiments were performed to assess COD, TSS and Colour removal as well as coagulation-flocculation at various alum dose(mg/L). The optimum dose obtained was 400 mg/L at a constant pH-6 , Alum dose 200 mg/L & Indfloc 441-1 mg/L. At a dose400mg/L, the optimum percent removal for TSS, COD and Colour reduction were77%, 58% and 71% respectively

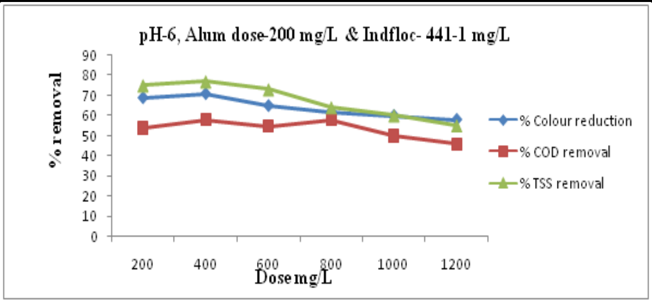

Fig 10: Graph indicates percent removal of TSS, COD and Colour reduction Vs Recycled Ballast sand Dose mg/L.

CONCLUSION:

1. The experimental study clearly demonstrated that the colour, TSS, and COD was removed successfully by chemical treatment. An attempt has been made in the present investigation to treat the recycle based paper mill wastewater by Coagulation, Flocculation and Ballast Flocculation.
2. It was observed that alum resulted in percentage removal of 68% TSS , 61% COD , & 43% Colour reduction at pH-6 for a dosage of 200 mg/L.
3. Ferric chloride resulted in percentage removal of 64% TSS , 58% COD , & 41% Colour reduction at pH-4 for a dosage of 400 mg/L
4. Results obtained for Combination of alum with CA-90 were 61% TSS , 56% COD , & 43 % Colour reduction for a dosage of 2 mg/L
5. Results obtained for Combination of alum with Indfloc-441 were 65% TSS , 62% COD , & 66 % Colour reduction for a dosage of 1 mg/L
6. Results obtained for Combination of alum +Indfloc-441 + Ballast sand were 80 % TSS, 65 % COD , & 75 % Colour reduction at for a dosage of 600 mg/L
7. Results obtained for Combination of alum +Indfloc-441 + Recycled Ballast sand were 77 % TSS , 58 % COD , & 71 % Colour reduction at a dosage of 400 mg/L.
8. The primary effect of adding the ballast sand is to dramatically increase the sedimentation rate by weighing down the floc. Ballast also strengthens the floc against shearing, allowing faster stirring rates. Typically the ballast can be recover and recycled back in to the waste stream reducing the need to the add replacement ballast and lowering operational expenses. Further, recycled ballast can reduce the require coagulation and flocculation chemical doses as recycled ballast acts as nucleation sites for floc formation. Because of the rapid mixing and settling rates, ballast flocculation units can handle significantly higher through puts for a given footprints, reducing capital and operation cost over a conventional unit.

REFERENCES:

1) American Public Health Association (APHA), (1995), "*Standard Methods for the Examination of Water and Wastewater",* Nineteenth Edition Washington D. C.
2) Arceivala, S. J., and Asolekar, S.R. (2007), "*Wastewater Treatment for Pollution Control and Reuse*", Third Edition, Tata Mcgraw-Hill publishing company Ltd.
3) Brown, J. (2003), "*Wastewater Treatment: The Experiences of the Scientific Research Council in Jamaica*".
4) Buzzini, A. P., Nolascob, M. A., Springer, A. M., and Piresa, E. C. (2006), "*Evaluation of Aerobic and Anaerobic Treatment of Kraft Pulp Mill Effluent for Organochlorines Removal",* Water Practice and Technology, 1(3).
5) Chuphal, Y., Shah, S., and Takur, I. S. (2007), "*Optimization of Upflow Anaerobic Sludge Blanket Reactor for Treatment of Pulp and Paper Mill Effluent",* Pollution research, 26(1).
6) CPCB in "*Water Quality In India (Status and trends) 1990 – 2001*"
7) Dangcong, P., and Qiting, J. (2007),"*Anaerobic Digestion of Alkaline Black Liquor Using an Up-Flow Anaerobic Sludge Blanket Reactor"* Journal of Chemical Technology and Biotechnology, 58(1).
8) Dangcong, P., Xingwen, Z., Qiting, J., Zhang, D., and Liangkui X. (2004), *"Effects of the Seed Sludge on the Performance of UASB Reactors for Treatment of Toxic Wastewater*", Journal of Chemical Technology and Biotechnology, 60 (2).
9) Driessen, W. J. B. M., Habets, L. H. A., Zumbrägel, M., Wasenius, C.O Paques (1999), "*Anaerobic Treatment of Recycled Paper Mill Effluent with the Internal Circulation Reactor*" 6th IAWQ Symposium on Forest Industry Wastewaters, Tampere, Finland.
10) Duggirala, Y. P. (2007), "*Biogas Generation from Bagasse-Based Paper Mills by Anaerobic Digestion*", Journal of Chemical Technology and Biotechnology, 51 (4).
11) Ilamurugu, K., Dhevagi, P., and Ramasamy, K. (2006), "*Anaerobic Treatment of Pharmaceutical Wastewater by Upflow Anaerobic Sludge Blanket Reactor",* Journal of Ecobiology 19 (4).
12) Kanat, G., and Saral, A. (2008), "*Estimation of Biogas Production Rate in a Thermophilic UASB Reactor Using Artificial Neural Networks",* Springer Science and Business Media.
13) Manivasakam, N. (1997), "*Industrial Effluents: Origin, Characteristics, Effects Analysis and Treatment*", Shakati Publication.
14) Mathur, B. V., and Kulkarni, R. M. (1998), "*Anaerobic Treatment of Inhibitory Compounds of Agro Based*

Pulp and Paper Mill Effluents - Various Preteatment Options", Journal of the Indian Pulp and Paper Technical Association, 10(3).

15) Metalf and Eddy (2006), *"Wastewater Engineering Treatment and Reuse*" Fourth Edition, Tata Mcgraw-Hill Publishing Company Ltd.
16) Nemade, P. D., kumar, S., and Zanje T. (2003), *"Importance of Alkalinity and Volatile Fatty Acids during Start –Up and Operation of UASB Reactor",* Indian Journal of Environmental Protection, 23(12).
17) Nemerrow, N. L. (1962), "*Theories and Practices of Industrial Waste Treatment*", Addison-Wesley Publishing Company Inc.
18) Panwar, M. P., Upadhyay, A. K., Sharma, P. N., and Marwal H. (2008), *"Raw Material Preparation and Cooking for Agro-Based Paper Manufacturing",* Journal of the Indian Pulp and Paper Technical Association, 20(3).
19) Prinen, T. (2008), "*Cost – Efficient Center Roll-Based Press Section to Boost Efficiency*", Journal of the Indian Pulp and Paper Technical Association, 20 (1).
20) Rajakumari and Munigesan (2002), "*Upward Anaerobic Sludge Blanket Reactor in the Treatment of Pulp and Paper Mill Effluent",* Indian Journal of Environmental Protection, 22(11).
21) Rao, A.G., Kusum, L., Raman, P., Kishore, V. N., and Ramachandran, K. B., (1997), "*Studies of Anaerobic Treatment of Synthetic Waste in a UASB Reactor*", Indian Journal Environmental Protection, 17 (5).
22) Satu, S., Lepisto, Jukka, A., and Rintala (1999), "*Start-Up and Operation of Laboratory-Scale Thermophilic Upflow Anaerobic Sludge Blanket Reactors Treating Vegetable Processing Wastewaters*", Journal of Chemical Technology and Biotechnology, 68 (3).
23) Shamsunder, K. M., and Manjunath, N. T. (2007), "*Phenomenon of Granulation Process in UASB Reactor",* Indian Journal Environmental Protection, 27, (9).
24) Show, K. Y., Tay, I. H., Wang, L. Y., and Lua, C. H. (2004), " *Effects of Stressed Loading on Startup and Granulation in Up Flow Anaerobic Sludge Blanket Reactors",* Journal of Environmental Engineering.
25) Shukla, Kumar, S., Kumar, V., and Bansal, M. C. (2008), "*Indian Paper Industry: Kyoto Protocol and Clean Development Mechanism",* Journal of the Indian Pulp and Paper Technical Association, 20(2).
26) Subramanian, S., Baskaranan, N., Rajan, B., Karuppannan, A., Mahesh, B., Sridharan, G., Ponnusamy, R., and Manickam, R. N. (2008), "*Recovery of Caustic, after Boil out in Paper Machine*", Journal of the Indian Pulp and Paper Technical Association, 20(2).
27) Trivedy, R.K. (1998), *"Advances in Wastewater Treatment Technology*", 1, Global Science publication, Aligarh.
28) Afshin Maleki; Mohammad Ali; Zazouli Hassan, Izanloo; and Reza Rezaee ;*2010.Composting Plant Leachate Treatment by Coagulation-Flocculation Process.*
29) American-Eurasian J. *Agric. & Environ. Sci., 5 (5): 638-643, 2009*
30) Aygun A.; Yilmaz T.; 2010. *Improvement of Coagulation-flocculation Process fortreatment of Detergent Wastewater Using Coagulent Aids.* Department of Environmental Engineering, Selcuk University.
31) Aboulhassan M. A.; Souabi S.; 2008. P*ollution reduction and biodegradability index improvement of Tannery effluents.* Int. J. Environ. Sci. Tech., 5 (1), 11-16, Winter 2008 ISSN: 1735-1472
32) Christian Desjardinsa ; Boniface Koudjonoub; Raymond Desjardins; 2001. *Laboratory study of ballasted flocculation.* John Meunier Inc., 4105 Sartelon St., Saint-Laurent, Que., Canada H4S 2B3, NSERC Industrial Chair on Drinking Water, EEcole Polytechnique deMontrl eal, C.P. 6079, Succ. Canada H3C 3A7 Water Research 36 (2002) 744–754
33) Huang Tian-yin; Xia Si-qing, Zhao Jian-fu,;Lu Xi-wu ; Huang Yong ;Liu Sui-bing ; 2006. *Removal of organics and nutrients from the combined sewage in shanghai using coagulation-flocculation process department of Environmental Engineering Southeast University Nanjing 210096*, P.R.China
34) *Industrial wastewater treatment,* M.N.Rao and A.K.Dutta oxford & IBH publishing co.ptv.ltd, new delhi, august 31st 1978.
35) Lofrano, G; Lgiorno, V.;Gallo M ; Raimo A.; Meri S. 2006.*Toxicity Reduction in Leather Tanning Wastewater by Improved Coagulation Flocculation process* Department of Civil Engineering, Campania Regional Agency for Environmental Protection Naples, Italy, Consorzio Disinquinamento Solofra,
36) Makhtar s.w. ;wahab ab M ; hasan M.; 2007 *Mechanical of coagulation proces of landfill lechate in removal COD,Ammonia(NH3) and Coor using polyaluminum chloride (PAC) and Alum.school of envirimental engineering* , university Malaysia Perlis

PART B (REFERENCES OF WEBSITE):

1) Envis Centre.html
2) www.mustseeindia.com/Kolhapur-weather
3) "National Productivity Council", New Delhi. (http://www.cpcb.nic.in/newitems/45.pdf)
4) http://en.wikipedia.org.

5) http://agriculture.indiabizclub.com/profile/874180~miraj+products+pvt.+ltd.~udaipur_india
6) http://water.epa.go/scitech/wastetech/upload/2005-07-28-mtb-ballasted-flocculation.pdf
7) http://en.wikipedia.org/wiki/Leather_production_processes
8) www.gate-international.org/documents/techbriefs/.../w019e_2002.pd
9) http://www.padepelearn.com/resources/kd/CoagJobAid.pdf
10) http :// www. docstoc.com/docs/20666186/AP42-915-Leather-Tanning
11) http://www.nanotech.wisc.edu/CNT_LABS/MSDS/Inorganic)