Physico Chemical Characteristics of Bagasse Wash Water in Agro Based Pulp and Paper Industries

[1]P. Ravichandran*, [2] K. Balaji and [3] C. Kannan
[1]Assistant Professor, [2]Assistant Professor and [3]M.E Scholar
[1] Department of Civil Engineering, Annamalai University, Annamalai Nagar, Chidambaram-608002, Tamil Nadu, India
[2] Department of Civil Engineering, University College of Engineering, Anna University, Panruti Campus, Tamil Nadu, India
[3] Department of Civil Engineering, Annamalai University, Annamalai Nagar, Chidambaram-608002, Tamil Nadu, India.

Abstract: Large quantities of bagasse are used as raw material in agro based pulp and paper industries. The study represents the physico-chemical characteristics of bagasse wash water in agro based pulp and paper industries in Tamilnadu. The effluent samples were collected from two different large scale integrated pulp and paper industries. Samples were brought imprecisely and essential physico chemical characteristics were analyzed in triplicate. The analysis were carried out for various parameters such as temperature, pH, turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total solids (TS), Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD), volatile fatty acids (VFA) as per the standard procedure. The results were presented the average characteristics of temperature of bagasse wash water was 32.5°C, pH of the raw wastewater was 5.21, turbidity of 21.70 NTU, Total Dissolved Solids of 2867 mg/l, Total Suspended Solids of 1259 mg/l, Settleable solids of 101 mg/l, Biological Oxygen Demand (BOD) of 3410 mg/l, Chemical Oxygen Demand (COD) of 5824 mg/l, and volatile fatty acids (VFA) as 1128 mg/l.

Keywords: Physical characteristics, Chemical characteristics, BOD and COD, Bagasse wash waster, Pulp and paper industry

I. INTRODUCTION

An enormous industrial growth has taken place throughout the world in the past few decades, to fulfill the increased demand of human civilization, which has created an overexploitation of available resources and caused pollution of water, land, and air. Pulp and paper industry is a highly energy and water intensive industry and also one of the biggest polluting sectors of water bodies (being the sixth largest water polluting sector as per a previous study by Pokhrel and Viraraghavan ,2004).

Pulp and paper industry is mainly categorized into three types according to their production capacity and raw materials usage i.e. small scale, medium scale and large scale. The small scale paper mills set up in the early seventies almost exclusively use agro waste/residues as raw materials for paper production whereas large scale mills, so far, have mainly been based on forest based woody raw material for paper production. As agro waste/residues such as rice straw, wheat straw and bagasse are relatively short cycled, regenerative and abundant, on the other hand the availability of forest based raw material is rather limited. Small scale paper mills suffer from high production costs, uneconomic operation, low quality and negative impacts on the environment. Furthermore, most small scale pulp and paper mills cannot economically provide chemical recovery and pollution control systems (Pooja Tripathi et al., 2013). The pulp and paper industry is one of the oldest industries in India. But there has been a tremendous expansion during last twenty five years. Varieties of papers and similar products are now manufactured in different mills throughout the country. The paper industry, as it stands now, is one of the largest industries in India and it is one of the major producers of paper in the world (Surabhi Yadav et al., 2007).

The Indian paper industry accounts for about 3% of the world's production of paper. Large integrated paper mills from private and public sector with a product mix of all varieties of paper (writing, printing, packaging, specialty, paperboards and newsprint) located in all regions and using conventional fibre such as wood and bamboo and also unconventional raw materials like recyclable waste paper, agro-residues, viz. bagasse and wheat straw; approximately 31% are based on wood, 47% on recycled fibre and 22% on agro-residues (Medhi .U.J et al, 2011). Typically in India, approximately 75% of the total fresh water supplied to pulp and paper industries emerges as waste water. In comparison to other industries, fresh water requirement in pulp and paper industry is quiet high, i.e, 150-200 m^3 per ton of paper produced (B. R. Yadav et al., 2011). To remove organic and inorganic substance from the wastewater, various treatments like physico chemical and biological treatment have been adopted before it was left into the environment.

Many authors have reported that the raw material preparation especially bagasse washing generates high amount of COD (Tewari, et al., 2009). Simultaneously, produces large amount of wash water from bagasse yard. Bagasse wash water stream has been segregated from other wastewater in almost all bagasse (agro residue) based pulp and paper industry due to the higher amount of BOD and COD content. Before going into treatment it is indeed to analyze the characteristics of wash water to adopt the suitable treatment processes. In this present study, the bagasse wash water were analyzed for its physico chemical characteristics in the two different large integrated pulp and paper mill industries in Tamilnadu where the bagasse (agro residue) was used as raw material.

II. MATERIALS AND METHODS

2.1 Collection of samples

The bagasse wash water was collected from the bagasse wash streams from two large scale integrated pulp and paper mills situated at Karur and Erode located in Tamilnadu, India. The samples were collected two times in the first and third week of each month such as August, September and October 2017. The grab samples were collected from both the industries in the plastic containers and brought imprecisely to the environmental laboratory in Department of Civil engineering, Annamalai University, Tamilnadu and it was refrigerated at 4° C prior to further analysis in the laboratory.

2.2 Analytical Techniques

The brought samples were analyzed in triplicate for each sample. The pH and temperature was measured by pH meter (model n) and thermo-probe at the site of collection. Colour of the effluent was noted by visual observation. Nephelo-Turbidity meter was used for the analysis of turbidity. The remaining wastewater characteristics parameter such as total suspended solids (TSS), total dissolved solids (TDS), total solids (TS), biological oxygen demand (BOD), chemical oxygen demand (COD) and volatile fatty acids (VFA) as per standard methods of analysis of water and wastewater (APHA 2005).

III. RESULTS AND DISCUSSION

The paper mill produces variety of writing and printing paper using using bagasse, a sugarcane residue, as a primary raw material. The wastewater generated from the paper mill consists of slightly brown water from stock preparation (Bagasse wash water), bleach section and from paper machine etc. The samples were collected two times in the first and third week of each month such as August, September and October 2017. The brought samples were analyzed in triplicate. The colour of the effluent was appeared to be light brown to yellowish brown in colour against the standard limit. This may be due to the presence of lignin compound present in the raw material used for paper production.The descriptive analytical values of physico chemical parameters of paper mill effluent were represented on the graphs which were plotted in the figure 3.1 to 3.11.

The temperature of the effluent is basically important factor for its effect on the other properties of wastewater and it was lie between 32 to 33.5 °C in both the mills which was depicted in figure 3.1. It was appeared as normal and the minimum temperature was observed as 30°C in first week of August, the maximum of 33.5 °C in third week of October and the standard deviation of 0.42 °C. The variation of pH and VFA were depicted in figure 3.2 and 3.11 respectively.

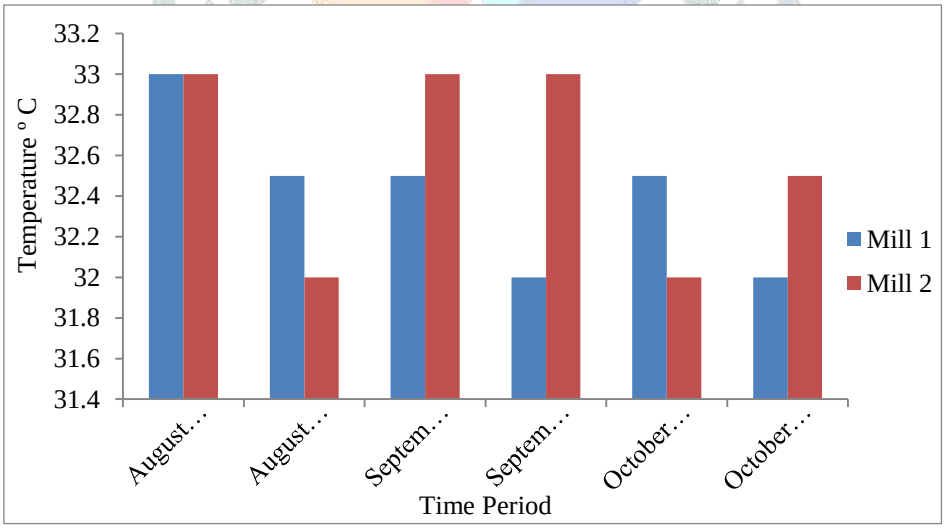

Fig. 3.1 Variation of temperature in bagasse wash water

The pH values were observed low in both the mill. The high VFA concentration and low pH is one of the unique characteristics of bagasse wash water. Based on the literature, when bagasse is received and stored in wet condition at bagasse yard in paper mill by sprinkling the water over the pile to prevent degradation and fire hazard. It carries around 3–4% of residual sugars after squeezed from sugar mill and during the storage these sugars are converted into organic acid by anaerobic microbial reactions takes place in the bagasse piles [Salabar et al. 1971]. These organic acids causing the pH reduction in bagasse pile and preserve the bagasse quality and get washed away during bagasse washing before pulping. The organic acids present in the pile exude out and join with bagasse wash water and increase the VFA content and reduce pH. The low pH of the wash water may be neutralized by adding alkaline solution if it is sent to the treatment process. The maximum and minimum pH values 5.85 and 4.61respectively and standard deviation were 0.42.

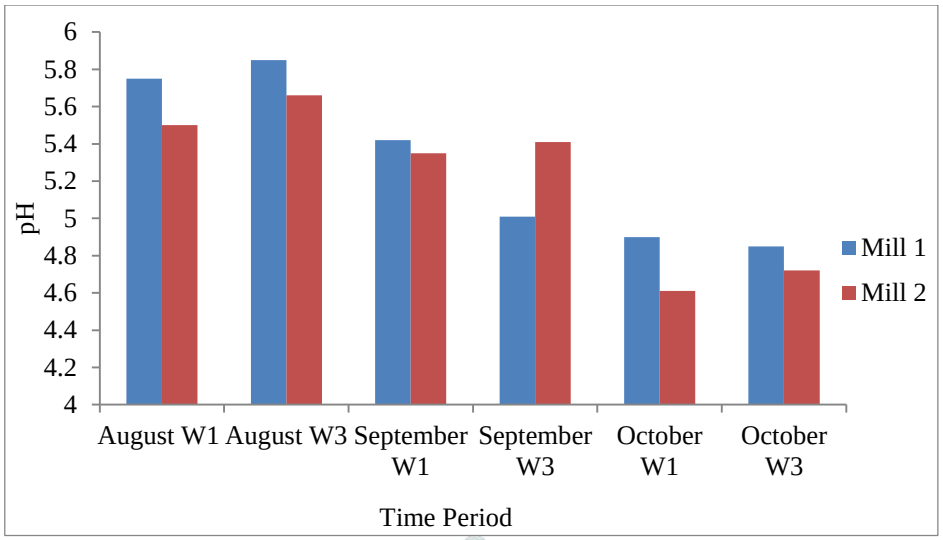

Fig. 3.2 Variation of pH in bagasse wash water

Turbidity is an expression of the optical property that causes light to be scattered rather than transmitted in straight lines through the wastewater sample. It is caused by suspended mater, such as organic and inorganic matter and soluble coloured organic compounds presence in the stocked bagasse pile. The mean value of turbidity was measured as 21.7 NTU with standard deviation of 1.67 for both the mill 1 and mill 2. Minimum and maximum values of turbidity were observed 18.5 NTU and 24.5 NTU respectively.

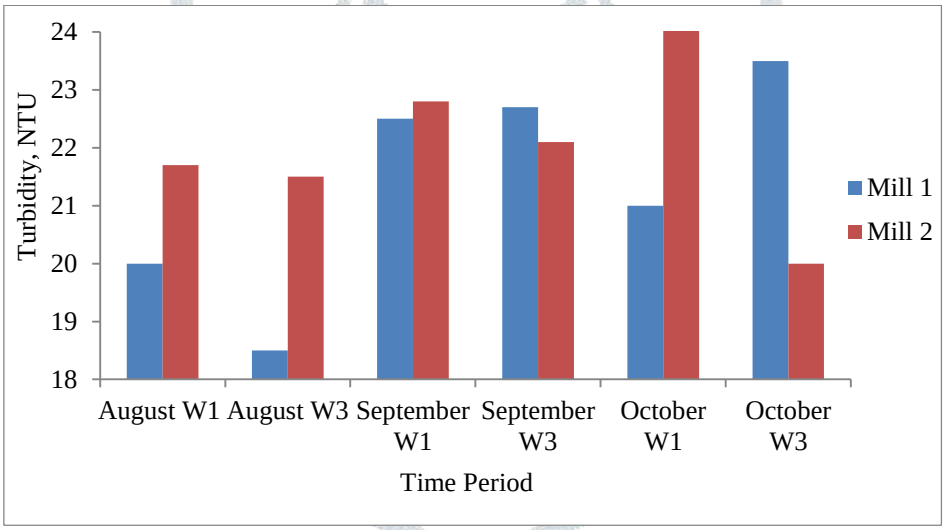

Fig. 3.3 Variation of turbidity in bagasse wash water

The variation of total suspended solids (TSS) was depicted in figure 3.4. The mean value of TSS was measured in bagasse wash water as 1259 mg/l with the standard deviation of 172. The higher concentration of TSS was due to the presence of bagasse fibres. This might cause the turbidity in the effluent. It was observed that the maximum and minimum values of TSS were 1665 mg/l and 1035 mg/l respectively. The average concentration of total dissolved solids (TDS) was 2867 mg/l with significant change in the standard deviation of 228. A total dissolved solid (TDS) is a parameter, which gives us the index of dissolved compounds, both organic as well as inorganic present in the said wastewaters. Among the inorganic dissolved components, free chlorine, sulphates, sulphides, carbonates, bicarbonates, predominate as the major anions; and calcium, magnesium, aluminium, iron and other heavy metal ions as the prevalent cations. Both inorganic and organic dissolved solids raise the TDS (mg/l) to a very high level. The organic dissolved compounds consist mainly of chlorinated compounds which were aroused from salts and chemicals used. The maximum and minimum values of TDS were observed as 3172 mg/l and 2072 mg/l respectively and it was represented in figure 3.5. Total solids were the combination of total suspended solids and total dissolved solids which were depicted in figure 3.6. Few settable solids were also observed which was insignificant with the characteristics of bagasse wash water. This was due to the inert inorganic substances and it was represented in the figure 3.7.

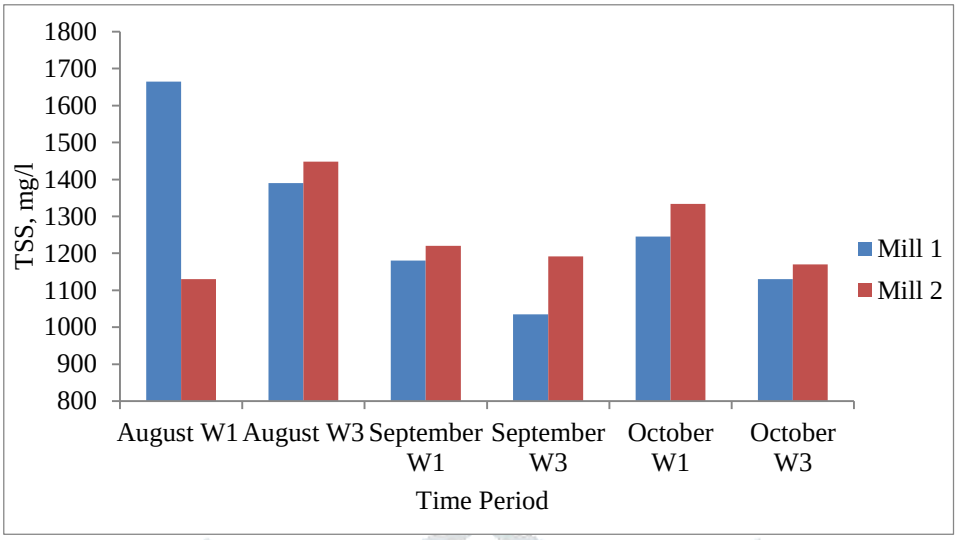

Fig. 3.4 Variation of Total Suspended Solids (TSS) in bagasse wash water

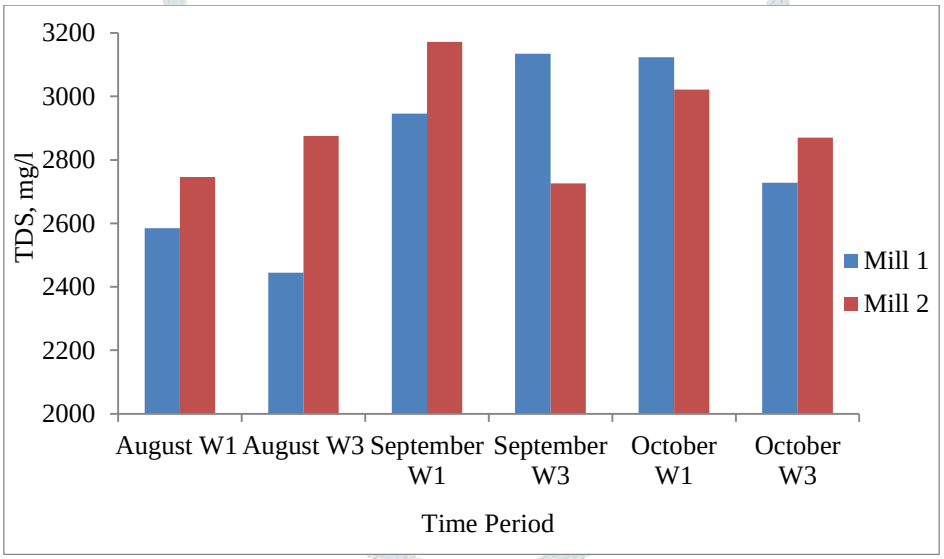

Fig. 3.5 Variation of Total Dissolved Solids (TDS) in bagasse wash water

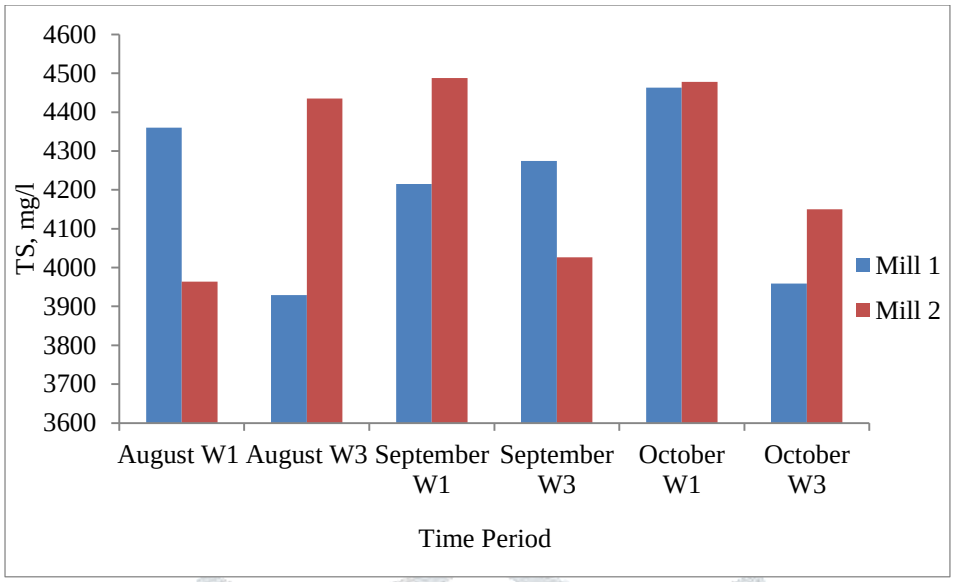

Fig. 3.6 Variation of Total Solids (TS) in bagasse wash water

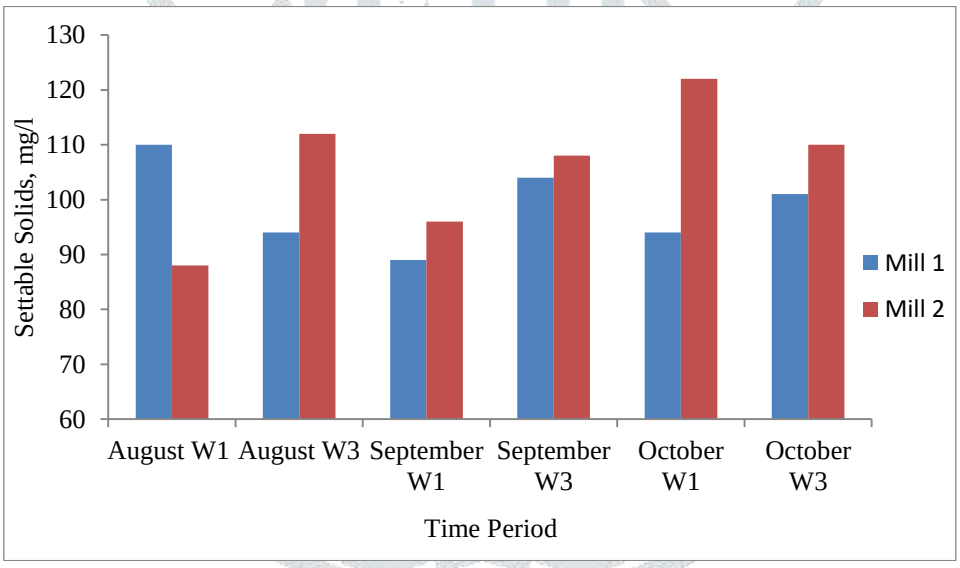

Fig. 3.7 Variation of Settable Solids (SS) in bagasse wash water

Biological oxygen demand (BOD) determines the amount of oxygen utilized by the microorganisms for oxidizing the organic matter. The average value of BOD was varying with the standard deviation of 3410±918 mg/l. Maximum (4212 mg/l) and minimum values (1226 mg/l) of BOD were observed during the sampling period as shown in the figure 3.8. The above mentioned values of varying BOD have been reported by many authors in literature due to the stocking of bagasse in the yard for periodical usage. The flowage of bagasse to pulp and paper mill is varied based on the seasons of the production of the sugarcane. The COD variations were represented in the figure 3.9. Chemical oxygen demand (COD) determines the amount of oxygen required to oxidize both organic and inorganic matters. Both BOD and COD are the most generic parameter for determining the pollution load in municipal sewage and industrial wastewater discharge. These parameters can also be used to determine the efficiency of treatment processes. Mean value of COD was 5824 mg/l. It was varied over the period of time with the significant changes in the standard deviation of 1736 and minimum (2416 mg/l) and maximum (8124 mg/l) values were recorded. From figure 3.1 and 3.10 the high VFA concentration and low pH is one of the unique characteristics of bagasse wash water. Salabar et al. (1971) reported that storage of bagasse the organic acids were oozed out and mixed with bagasse wash water during bagasse washing. Thus increases the VFA content and reduce pH. The maximum and minimum values were recorded as 2350 mg/l and 572 mg/l respectively with the standard deviation of 655. The mean value of VFA content was measured as 1128 mg/l.

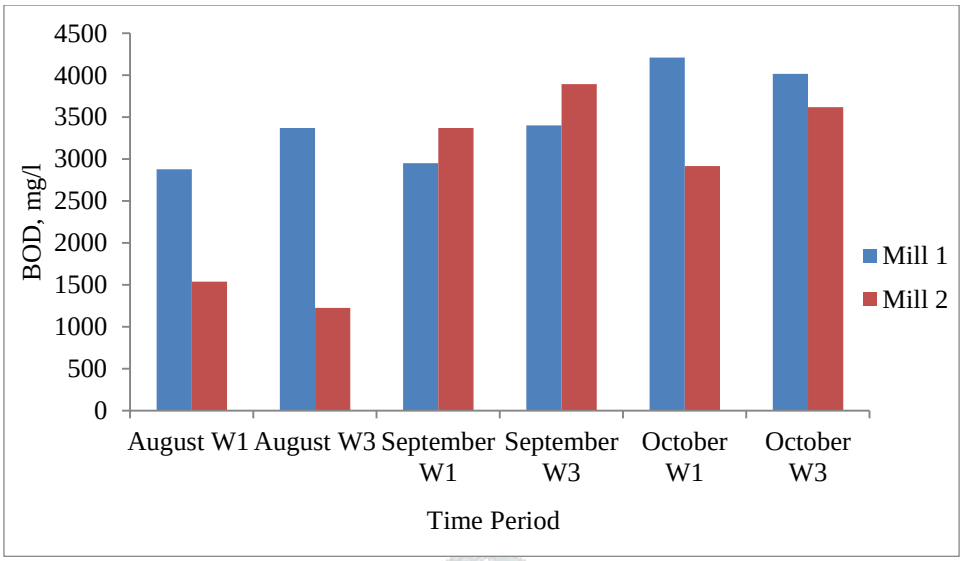

Fig. 3.8 Variation of Biological Oxygen Demand (BOD) in mill 1 and mill 2

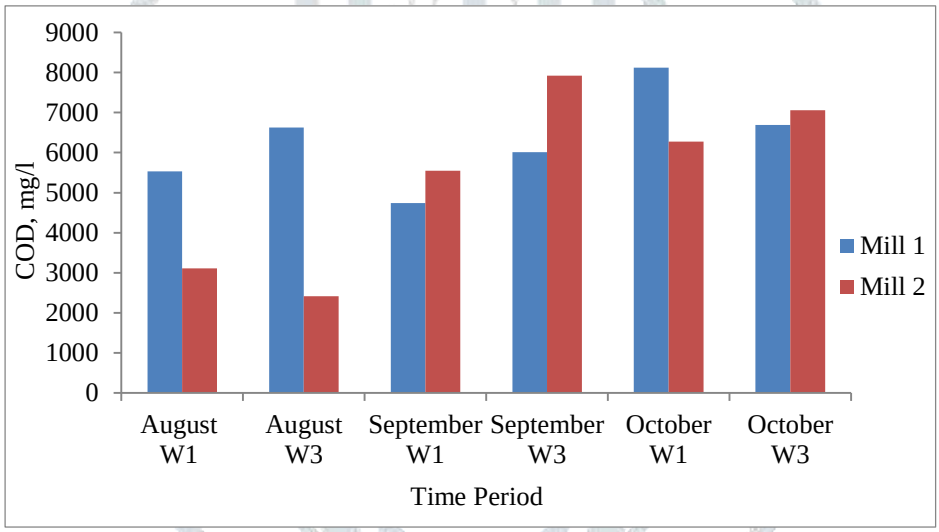

Fig. 3.9 Variation of Chemical Oxygen Demand (COD) in mill 1 and mill 2

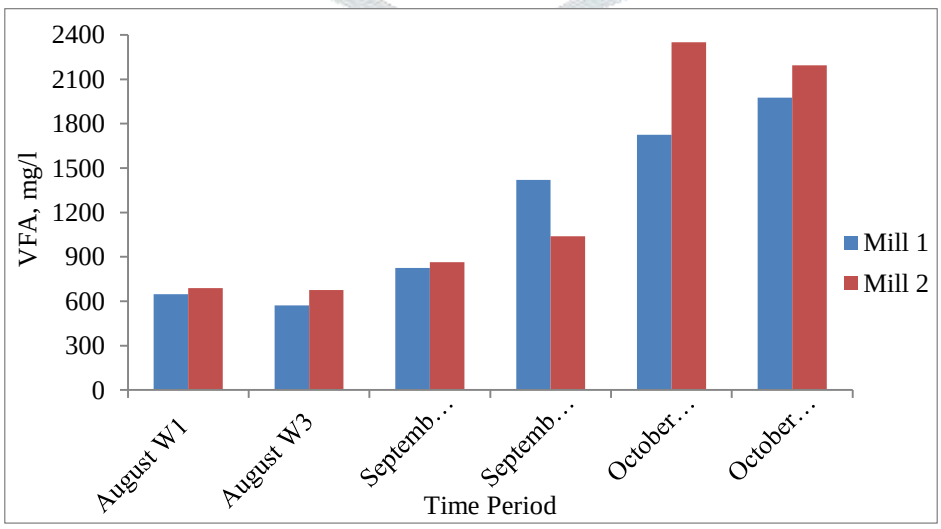

Fig. 3.10 Variation of Volatile Fatty Acids (VFA) in mill 1 and mill 2

IV CONCLUSION

Pulp and paper mills are categorized as a core sector industry and are the fifth largest contributor to industrial water pollution. The physico-chemical characteristics of effluent from this mill revealed that the raw material preparation especially bagasse washing generates high amount pollution load in terms of BOD and COD which required adequate treatment before discharged. The other parameters such as colour light brown, temperature was seems normal, pH appeared as low due to VFA accumulation, turbidity was slightly high, TSS, TDS, and TS were high and needs primary treatment for both mills.

V ACKNOWLEDGEMENT

Authors are thankful to pulp and paper industries situated at Karur and Erode, Tamilnadu for providing the wastewater samples and also authors would like to thank Mr.Shanmugam, Mr.Vivek and Dr.Chinnaraj Environmental Division for providing necessary and relevant information.

REFERENCES

1. Anju Bhatnagar, Assessment of Physico-chemical characteristics of paper industry effluents, Rasayan Journal of Chemistry. Vol. 8, No.1, 143-145, 2015.
2. B. R. Yadav and A. Garg, Treatment of pulp and paper mill effluent using physico-chemical processes, Indian Pulp and Paper Technical Association journal, 23 (2), 2011, 155-160.
3. D. Pokhrel and T. Viraraghavan, Treatment of pulp and paper mill wastewater – a review, Science of Total Environment, 333, 2004, 37-58.
4. G. Thompson, J. Swain, M. Kay, C.F. Forster The treatment of pulp and paper mill effluent: a review, Bioresoueces Technology 77 (2001) 275-286.
5. Malaviya.P, and Rathore.V.S, Seasonal variations in different physic-chemical parameters of the effluents of Century Pulp and Paper Mill, All Kuna, Uttarakhand. , Journal of Environmental Biology,28 (2),219-224, 2007.
6. Medhi .U.J, Talukdar A.K,and Deka. S. Impact of paper mill effluent on growth and development of certain agricultural crops Journal of Environmental Biolology, (32), 2011, 185-188.
7. N.L.Devi, I.C.Yadav. Q.I. Shihua, Suerndra Singh. S.L. Belagali Physicochemical characteristics of paper industry effluents- a case study of South India Paper Mill (SIPM), Environmental Monitoring and Assessment, Springer Science 177:23-33(2011).
8. Pooja Tripathi, Virendra Kumar, Gyanesh Joshi, Sat Pal Singh, Suresh Panwar, Sanjay Naithani, Raman Nautiyal, A Comparative Study on Physico-Chemical Properties of Pulp and Paper Mill Effluent Int. Journal of Engineering Research and Applications, Vol. 3 Issue 6 2013, pp 811-818.
9. P. Ravichandran, P.Prakash, Physico Chemical Characteristics Of Bagasse Based Pulp And Paper Mill Effluent By Varying Season International Open Access Journal Of Modern Engineering Research, ISSN: 2249–6645, Vol. 6 , Issue 5 , May 2016, 75.
10. Paper Industry overview 1-4, Indian Paper Manufacturers Association (IPMA), 2014.
11. Surabhi Yadav and Nidhi Yadav Physicochemical study of Paper Mill Effluent: To asses pollutant release to Environment, International Journal of Environmental Sciences, Volume 4, No 5, 2014.
12. V.P. Kesalkar, Isha. P.Khedikar, A.M.Sudame Physico-chemical characteristics of wastewater from Paper Industry, International Journal of Engineering Research 2012, 137-143.
13. Salabar J, Maza F. Ritter Biological treatment process for bagasse storage. Non-wood plant fibre pulping progress Report no. 2. TAPPI Press; 1971. p. 51–78
14. Subrahmanyan P.V.R. Waste management in pulp and paper industry. Journal of Indian Association for Environmental Management. 17, 79-94, 1990.
15. Tewari, P.K., Batra, V.S., Balakrishnan, M., 2009 Efficient water use in industries: cases from the Indian agro-based pulp and paper mills. J. Environ. Manage. 90, 265–273.