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CONTROLLING ODOUR PROBLEM IN KRAFT PAPER INDUSTRY

(INNOVATIVE WASTEWATER TREATMENT AND MONITORING SOLUTIONS)


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Abstract:

Kraft paper is commonly used as packaging material for food, chemicals, and other consumer goods due to its durability and eco-friendly nature. However, the Kraft paper often has an obnoxious odour which makes it unacceptable for certain application, especially food packaging. The odourants in the kraft paper may originate from different sources. Most of the Kraft paper mills use unbleached waste paper as the raw material with closed-water circuits that increases the BOD, COD and bacterial load of the process water, which in turn increases the odour levels of the water and hence the produced Kraft paper. In this study, to reduce the odour intensity of the water and paper, we treated the water with a unique combination of antimicrobial enzyme and oxidizer formulations to control the microbial load and odourant compounds, like hydrogen sulfide. The odour intensity was measured using an electronic-nose system designed for monitoring obnoxious gases in pulp and paper industry. During the treatment period of 3 months, a significant reduction in microbial load, odour intensity and other parameters of the process water was observed. This paper presents insights on the results obtained from the study.

Keywords: Kraft Paper, wastewater recycle, microbial growth, odour intensity, Electronic Nose

1. Introduction:

Many grades of paper have odour problem and this problem is more in case of Kraft Paper and board paper manufacturing. The causes of odour in Kraft papers are different from the chemical pulping industry, where mostly the chemicals used for bleaching the pulp is one of the main causes of odour in the paper and the surroundings.[1-2] The odourous compounds in paper may originate from quite different sources, and the odour can be a part of the raw material or a part of the process. In India, apart from agricultural residues as raw material, many Kraft paper mills are based on 100% recycled and unbleached wastepaper, inherently having significant quantity of waxes, gums, coating binders, print ink and volatile compounds, all having a characteristic odour. Therefore, the chemical nature of the raw material itself is a major source of unpleasant smell and odour in Kraft paper mills.

The odour problem is further amplified due to the practice of using recycled wastewater for pulping and paper manufacturing. Due to environmental regulations and zero liquid discharge policies, most Kraft mills are operating with closed-circuit water system. Many of the mills recycle the wastewater for paper manufacturing without any proper treatment. In such mills, microbiological activity is also a major source of odour. The odour is generated due to the anaerobic conditions in pulp storage, effluent clarifier and clarified water storage tanks, which allows decomposition or organic matter by different types of microorganisms, including sulphur reducing bacteria (SRB) which release odourous compounds like hydrogen sulfide (H_2S) and volatile acids[3,4]. Often, the untreated wastewater is recirculated in a closed-loop for several weeks or even months with minimum addition of fresh raw water, which further aggravates the odour problem due increasing organic load, COD, BOD and other nutrients load which encourages excessive growth of odour-causing bacteria over a period of time.

Due to the above reasons, kraft paper may never be completely odourless. Since there are multiple factors involved, the system is very dynamic and hence odour levels fluctuate with conditions. Nevertheless, kraft paper mills need effective and sustainable solutions for odour control because the main use of Kraft paper is packaging food products, medicines, chemicals and other consumer products for storage and transportation, without affecting their flavor, taste and quality[4]. Odourous compounds from packaging materials may transfer to food material and medicines due to physical diffusion and permeation, hence resulting in consumer dissatisfaction and financial losses to the Kraft paper mills.

The odour problem is also complicated by the lack of simple and easy-to-use assessment methods for odour measurement. At present the odour quality and intensity of the produced Kraft paper is determined by human nose. However, the practical application of human nose for odour recognition is severely limited by the fact that our sense of smell is very subjective. Human nose may sometimes confuse an odour with other odours and if many human noses are subjected to the same smell, they may identify it differently. Human nose gets acquainted to a smell when sensed for too long and therefore may not serve the purpose. So, most of the times the true odour intensity of the paper and different parts of the manufacturing process is incorrectly determined, which makes it very difficult for mill operators to take any decision to control the odour. Therefore, the odour experienced by the consumers may differ from the odour detected by the mill quality control system.

In this study, to reduce the odour intensity of the water and paper, we treated the wastewater with a unique combination of antimicrobial formulations and oxidizing agents to reduce the microbial load and concentration of odourant compounds, like hydrogen sulfide. During the treatment, the odour intensity of the wastewater, air and paper samples was measured using an innovative and patented 'Electronic-Nose' system, designed for monitoring obnoxious gases in pulp and paper industry by OlfaMach Engineering Solution Pvt Ltd., Nagpur. The main advantage of 'E-Nose' is that it provides a numerical value for the odour intensity with more precision and accuracy in accordance with ASTM E544 -99 12- point intensity scale[6-8].

2. Materials and Methods

2.1 Materials

Bactosafe P and Enzytreat Pro were used as antimicrobials to reduce the microbial growth in the wastewater. The antimicrobial formulations were developed by testing various combinations of antimicrobial enzymes (belonging to oxidoreductases, proteases and polymer hydrolases category) against the microbial flora (bacteria and fungi) isolated from an Indian Kraft paper mill wastewater which is experiencing odour problem. Also, to control the odour due to H_2S, SulfoTreat R was used to remove the sulphides from the wastewater, while SulfoTreat P was used to prevent H_2S formation by sulphur reducing bacteria. SulfoTreat R is based on mild oxidizing agents, while SulfoTreat P is formulated using metal ions which effectively inhibit biogenic hydrogen sulphide formation. All these formulations were developed by Catalysts Biotechnologies. Pvt. Ltd, Delhi.

2.2 Treatment site

The study was conducted in a Kraft Paper mill based in South India. The mill manufactures Kraft paper using recycled wastepaper and is one of the leading manufacturers of wide GSM and BF ranges of Kraft Paper in India with an overall capacity of more than 100,000 TPA. The mill has a twin wire (top layer and bottom layer) paper machine, which is a modification

of the Fourdrinier process using two wire mesh belts instead of one to form the pulp into paper. The mill operates throughout the year using recirculated wastewater which results in high odour in the final product as well in the surroundings. The wastewater (back water) from the top and bottom layers is collected in the 'Back Water Tank' which is treated using a 'clarifier' and the treated water is stored in a 'Treated Water Tank'. The treated water is recirculated in the process for pulping and pulp dilution for paper manufacture.

2.3 Treatment and Analysis

Bactosafe P and SulphoTreat P were continuously dosed in the treated water tank and Back water tank at 8 and 20 ppm, respectively, while Enzytreat Pro and SulphoTreat R were dosed in the Top Layer and Bottom Layer tray water at 5 and 15 ppm, respectively, as shown in Figure 1. The dosing was done on the basis of total volume of water present in the system.

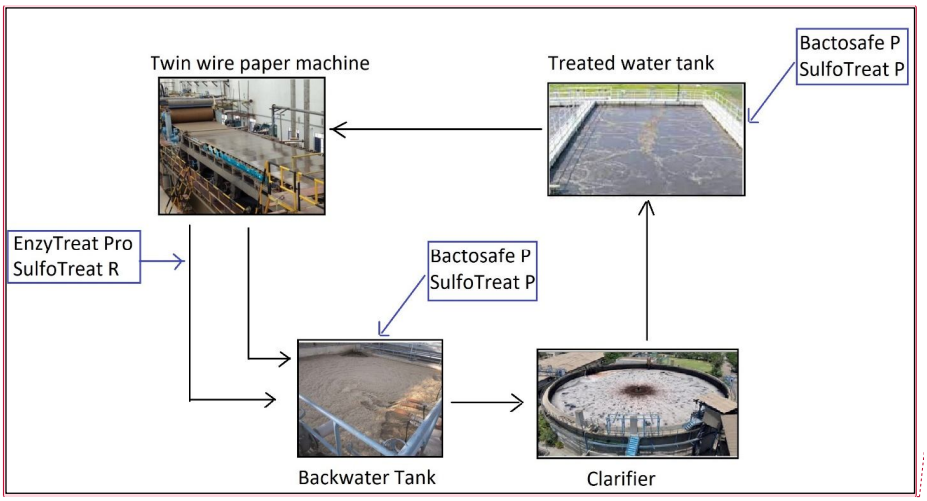

Figure 1. Schematic showing the dosing points at the treatment site

The dosing was done continuously for a period of 3 months during which the chemical and microbial analysis of wastewater samples were caried out using standard microbiological, chemical and Gas Chromatography methods, while the odour analysis of wastewater, paper and air samples was done using an Electronic-Nose instrument, specifically designed and developed to monitor odour intensity in pulp and paper mills. The analysis was done in triplicates and the values reported in this paper are the average values.

3. Results and Discussion

3.1 Effect of treatment on microbial counts

Figure 2 (a-b) shows the trends of microbial load in different water samples in terms of Total Bacterial Count (TBC) and Total Lactobacillus Count (TLBC). Before starting the treatment, both TBC and TLBC microbial counts were very high, in the order of 10^7-10^8 CFU/mL. Within 15 days of treatment, the TBC and TLBC counts were drastically reduced by more than 95% and after 30 days of treatment, the TBC and TLBC counts were reduced further to around 10^4 CFU/mL. In the next 60-70 days, the bacterial counts were further reduced to 10^3-10^4 CFU/mL. Therefore, the treatment resulted in very good reduction in bacterial growth, which would subsequently result in reduced byproduct accumulation and odour.

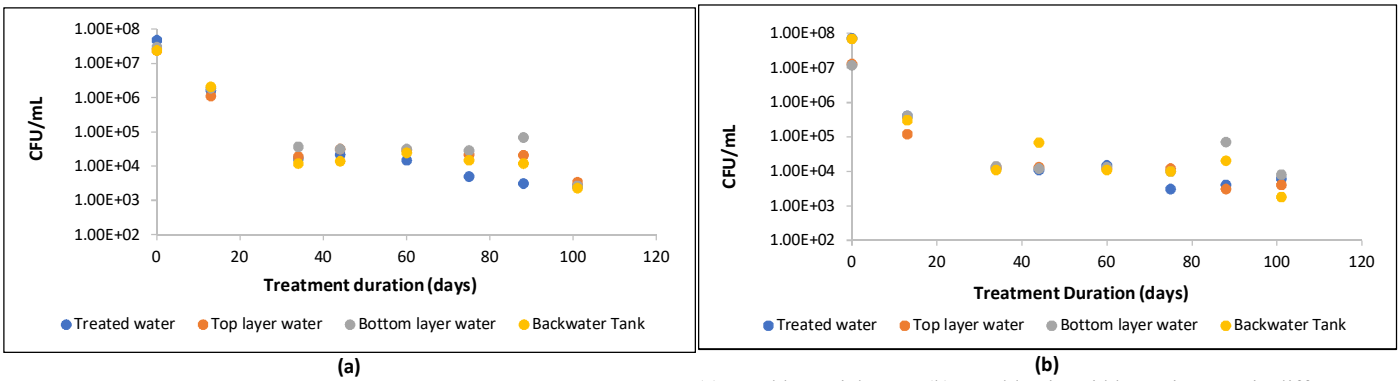

Figure 2. (a) Total bacterial count (b) Total lactic acid bacteria count in different water samples during treatment

3.2 Effect of treatment on COD and byproduct concentration in water samples

Figure 3 depicts the average concentration of COD, ammonia and sulphides in the four wastewater samples. A substantial reduction in COD (20%), ammonia (20.3%) and sulphide (40.16%) were observed within 30-40 days of treatment. This shows that the treatment inhibited the growth and metabolism of bacteria resulting in lower accumulation of odour causing ammonia and sulphides. Since SulphoTreat R is formulated using oxidizing agents, it could also have an effect on the COD of the water, and therefore a considerable drop in COD was also observed during the treatment. After a period of 40-45 days, very slow reduction in the sulphide and COD levels was observed, while good reduction in ammonia continued during the next 60-70 days treatment period.

Gas chromatography analysis of the samples during treatment also revealed that there was a significant drop in volatile acids like acetic acid, lactic acid and alcohols like butanol and propanol during the treatment as shown in Fig 4 (a) and (b). Specifically, there was a very high reduction (>90%) in the lactic acid concentration, and by the end of 75th day of treatment, the lactic acid level in the treated water sample was almost nil, while in other samples it ranged between 1000-4000 ppm, which is a very significant drop from the values obtained when the treatment was started (>15000 ppm). This shows the antimicrobial combinations used for the treatment had a very high inhibitory effect on the lactic acid bacteria and other bacterial flora in the wastewater.

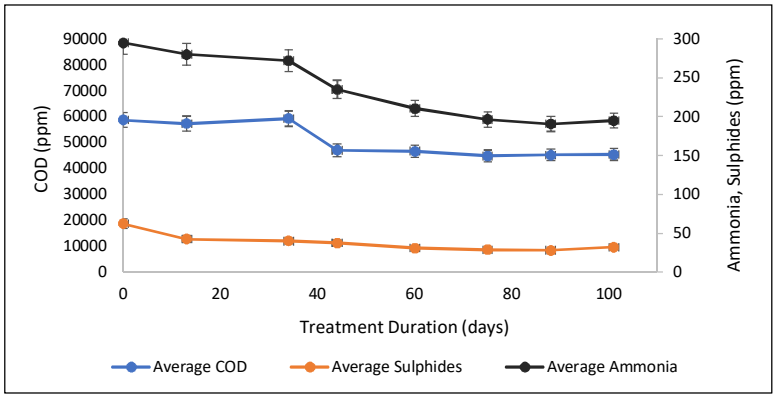

Figure 3. Reduction in average ammonia, sulphides and COD values of the wastewater during the treatment

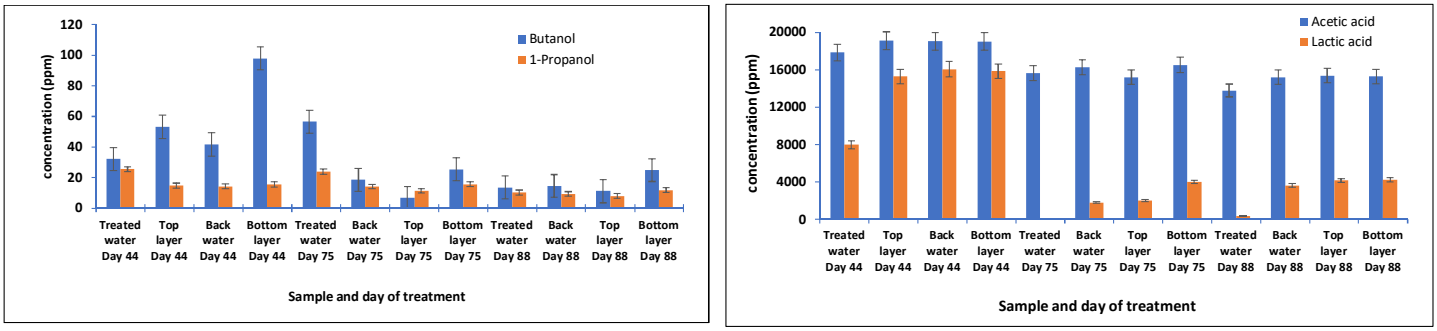

Figure 4. Reduction in (a) butanol and propanol (b) acetic acid and lactic acid concentration in various samples during treatment

3.3 Odour intensity profile

Figure 5 shows the odour intensity (before starting the remediation treatment) measured by electronic nose system at various locations. The Y axis represent the intensity scale as defined by ASTM E544 - 99. Based on the odour intensity levels of the sampling points stated above, it was found that the treated water sample had the maximum odour intensity, and that the high intensity of odour in treated water was directly affecting the obnoxious odour associated with of the paper samples, since the treated water was recycled back into the process. Hence, over a period of 60 days the odour profile of the treated water sampling was minutely studied with respect to its response to the treatment technique used. Figure 6 shows the results of day-wise odour profile of the treated water sample in response to the treatment technique used. The electronic nose system is a sensor-based technology. In Figure 6, S1 to S8 are various sensors employed for measurement of the odour intensity. The Y- axis represents the change in voltage, which is directly proportional the level of odourant concentrations. It could be observed that there was linear fall in the overall odour intensity of the treated water, giving a positive affirmation that the remediation technique proposed was effective.

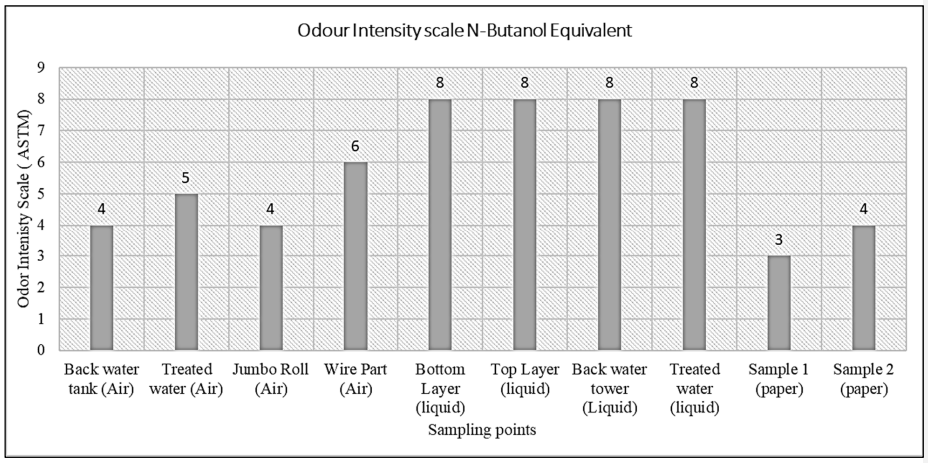

Figure 5. Odour intensities at various locations before the start of remediation process

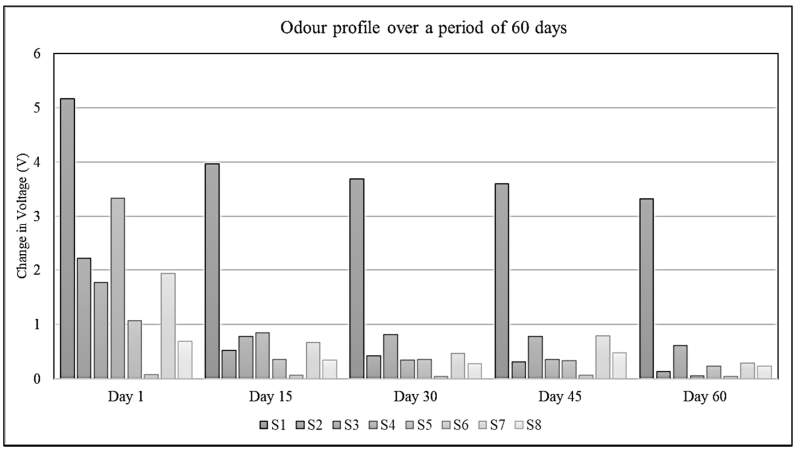

Figure 6. Odour profile of Treated water sampling point over a period of 60 days (from the start of treatment technique)

4. Conclusions

The treatment process using Bactosafe P, Enzytreat Pro, and SulfoTreat effectively reduced the microbial load in the Kraft paper mill wastewater, as well as the chemical oxygen demand, ammonia and sulphide levels. Microbial growth has direct impact on the odour intensity of the wastewater, and hence the produced paper. Inhibition of microbial growth and prevention of ammonia, sulphide accumulation as observed in this study substantially reduced the odour levels. The odour intensity measured by the electronic nose shows considerable reduction in odour levels during the treatment period, indicating that the treatment technique is providing satisfactory results in reducing the odour levels at various key locations in the paper mill. However, the overall odour scenario at the industrial site was observed to be capricious. A continuous measurement of odour intensity levels is needed to provide effective remediation technique for the effective removal of obnoxious odour associated with the final outcome in the form of paper.

5. Acknowledgement

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6. References

1. Bordado, J. C., & Gomes, J. F. (2003). Emission and odour control in Kraft pulp mills. Journal of Cleaner Production, 11(7), 797-801.
2. Bajpai P (2014) Emissions from pulping, In: Biological Odour Treatment, SpringerBriefs in Environmental Science, 9–17. DOI: 10.1007/978-3-319-07539-6_2
3. Liang, C. C. V. (2008). Reduced sulphur compounds in ambient air and in emissions from wastewater clarifiers at a Kraft pulp mill (Masters dissertation, University of Toronto).
4. Rava, E. M. E. (2008). Management of hydrogen sulphide generation at a Kraft paper mill (Doctoral dissertation, University of Pretoria).
5. Bajpai, P. (2023). Environmental Issues of the Pulp and Paper Industry. In: Environmentally Benign Pulping. SpringerBriefs in Molecular Science. Springer, Cham. DOI: 10.1007/978-3-031-23693-8_3
6. Prasad, P., Raut, P., Goel, S., Barnwal, R. P., & Bodhe, G. L. (2022). Electronic nose and wireless sensor network for environmental monitoring application in pulp and paper industry: a review. Environmental Monitoring and Assessment, 194(12), 855.
7. Deshmukh, S., Jana, A., Bhattacharyya, N., Bandyopadhyay, R., & Pandey, R. A. (2014). Quantitative determination of pulp and paper industry emissions and associated odour intensity in methyl mercaptan equivalent using electronic nose. Atmospheric Environment, 82, 401-409.
8. S. Deshmukh, H. J. Purohit, A. N. Vaidya and A. -C. Romain, (2017) MSW odor quantification using electronic nose and chemical analyzers: Relative exploration of prediction capabilities and robust model development, ISOCS/IEEE International Symposium on Olfaction and Electronic Nose (ISOEN), Montreal, QC, Canada, 1-3, DOI: 10.1109/ISOEN.2017.7968853.