

A Natural, Ecofriendly, & Sustainable Approach towards Odor Control in the Recycled Kraft Pulp & Paper Industry



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Abstract: A significant problem facing the pulp & paper industry is anaerobic papermaking in the recycled kraft paper mills. The processing conditions in the recycled kraft paper making facilitates many facultative and anaerobic pockets and environment wherein the specific classified bacteria can grow & multiply in the absence of oxygen. These conditions arise from making paper with:

1. Less utilization of fresh water with repetitive uses of the same process water in closed loop system
2. High moisture (7-8%) and anaerobic conditions in the final paper role with starch coated on the surface
3. Large volume storage tanks for recycled water

These anaerobic conditions lead to, increased buildup of microbial load in the total water system and hence in the paper. Increased microbial load results in high use of specialty chemicals, increased paper odor, & decreased paper strength.

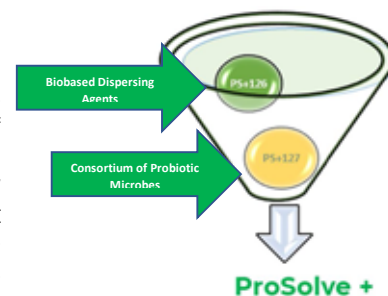
The technology & product 'Probiotic Odour Control program' presented in this paper has aimed at controlling the increase in microbial load in the complete water system in the paper mill. This is achieved by utilizing the power of good microbes that can grow very fast in the anaerobic conditions. The innovative product & technology presented in the current research eliminates the utilization of biocides & hypo which otherwise makes the process water more anaerobic because of their higher contribution to COD. The biological approach to reduce the odour in the final paper will not only add in the quality but also will help in building a good & healthy working condition in the paper mill.

Key words: Odour, Volatile fatty acids (VFAs), biocides, aerobic, anaerobic, probiotics, bio-dispersant, environmental issue, biodegradable.

Technology at glance

ProKlean has come up with a unique technology & product 'Probiotic Odour Control program', a uniform blend of bio-dispersant and probiotic microbes. A dual formation product contains 'PS+126' a bio-dispersant & 'PS+127' a fermentation derived probiotic microbe suspension.

The unique microbial consortium contains probiotic organisms capable of producing organic acids and includes a special type of sulfur consuming bacteria. The product when used in the process populates this consortium of microbes in the anaerobic conditions of the mill and competitively exclude the already existing bad anaerobic microbes responsible for the volatile fatty acid production¹. The unique blend of bio-dispersant present in the dual formation helps in breaking the biofilms responsible for producing volatile fatty acids & separating them from the final paper. Thus, the dual formation helps not only in reducing the VFA from the paper but also making the overall system healthy & odour free.

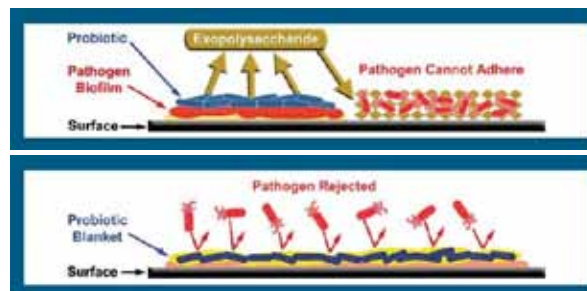


Key Features of the Technology

'Probiotic Odour Control program' is first of its kind of technology for odor control in kraft paper by eliminating biocides & hypo, reducing VFA, stabilizing ORP, reducing SRB, and reducing the overall bad odor from the final paper & environment. Some of the key features of the technology include:

1. Consortium of Probiotic Microorganisms

- a. Capable of producing organic acids responsible to kill the pathogenic growth in the stagnant water bodies
- b. Excrete anti-adhesion molecules (Exo polysaccharides) that changes the surface hydrophobicity²
- c. Prevents the growth of unwanted microorganisms/pathogen on all the contact surface



- d. Prepares a productive good surface for incoming good bacteria
- e. Controls volatile fatty acid formation

2. A microbe suspension along with bio-dispersant

- a. Can penetrate & wet the hidden parts of the machine & the chests
- b. Destroys the already formed biofilm by releasing the biosurfactants
- c. Very low in the toxicity & higher in the biodegradability



3. Special bacteria capable of consuming sulfur

- a. Proven to survive on the inorganic & organic sulfur compounds
- b. Effective in neutralization of H₂S & other sulfur compounds produced in the system
- c. Improves the oxidative conditions (ORP) of the water⁴
- d. Inhibits microbiologically influenced corrosions (MIC)⁵

Why 'ProSolve +' is a better option?

	BIOCIDE	Probiotic Odour Control Program
1	Bacteria tend to develop resistance to biocides entailing frequent change of biocides	On the contrary, Probiotic Odour Control Program is a blend of several beneficial micro-organisms and bio-chemicals and hence the odour causing bacteria will not be able to build resistance
2	Starch carried over in the system acts as nutrients to the bacteria and feeds their growth and the closed loop water system results in build-up of anaerobic bacteria and these pose a challenge to biocides	The bio-chemicals in Probiotic Odour Control Program ProSolve+ break down the residual starch while the robust beneficial micro-organisms inhibit the growth of aerobic and anaerobic bacteria.
3	Hydrogen sulphide is generated in the wastewater system due to Sulphate Reducing Bacteria (SRB) ⁶ and biocides are ineffective against these	Some of the microorganisms in Probiotic Odour Control Program prevent the growth of SRB and, hence, prevent generation of Hydrogen Sulphide
4	As water quality deteriorates fast, the use of make-up water goes up significantly	Make up water requirement goes down as water quality tends to be better

Results & Discussion

Probiotic Odour Control Program as odour reduction program is running successfully across India in many of the recycled Kraft paper mills. Application of the product at various points in the different mills is decided based on the mill conditions such as the previous odour reduction program, daily paper production capacity, furnish type & weather conditions. At the same time technical audit of the mill is carried out by an experienced team to collect the blank data including ORP & VFA of the existing system and to decide the correct dosing points for product application. Results obtained in one such field trial is presented below as a case study of ProCharta ProSolve+.

ProCharta ProSolve+ Case Study

Application	-	Odour control and Slimicide in Kraft Mills
Product	-	ProCharta ProSolve+
Trial duration	-	Program running for 11 months
Furnish	-	Indian 60% & OCC 40%
Production	-	220 TPD
GSM	-	120 to 240

Pre-trial odor control program

- Oxidative Biocide: 300g/MT
- Hypo: 120-150kg/day

Pre-trial parameters

- ORP: negative 80
- VFA: 8670 ppm

Below are the results obtained during the trial period for improvement in the ORP of the water bodies from different mill locations & VFA of the paper.

1. Improvement in ORP

The negative ORP conditions in a mill arises because of the continuous increase in the organic load (COD) which consumes dissolved oxygen available in the system⁷. Eventually, the increased anaerobic conditions result in the pathogenic microbial growth responsible for the volatile fatty acids & other sulphurous compounds. Consistent dosing of 'probiotics program' helps in breaking the pathogen biofilm through the bio-dispersant & facilitates the growth of good probiotic microbes in the system. The good probiotic microbes grow on the available COD as carbon source & further suppresses the other pathogenic growth in the water. This results in the improved oxygen availability in the system & so improved ORP. Results are summarized in the figure No.1 & 2

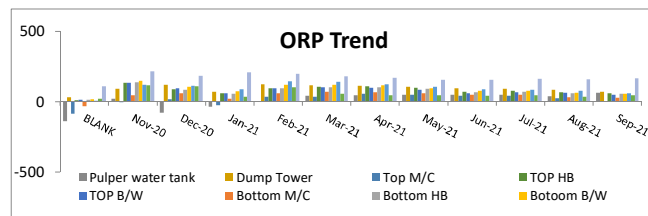


Figure No. 1: Month wise ORP trend at different locations in a paper mill

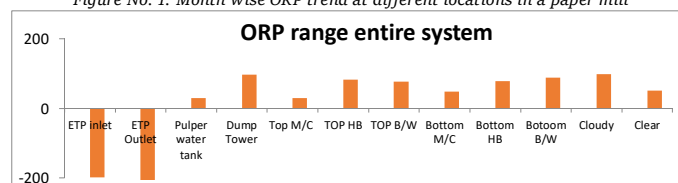


Figure No.2: ORP range in the entire water system

2. Reduced VFA Trend

Biocides & Hypo can neutralise the bacteria when they come in contact, while certain types of anaerobic bacteria continue to thrive in inaccessible areas and are difficult to control. These bacteria produce volatile fatty acids which are considered as the main causes of odour in the final paper. The bio-dispersant part of the 'Probiotics', formulation breaks the biofilms in the inaccessible areas while the consortium of probiotic and beneficial microbes populates over the anaerobic pathogenic bacteria thus controlling the production of VFAs. The overall effect is reduction of VFAs in the overall water system & hence on final paper. Results are summarized in the figure No. 3 & 4.

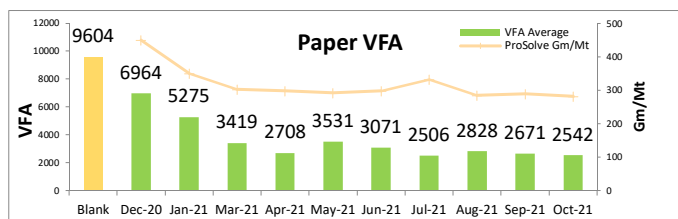


Figure No. 3: Average Paper VFA for last 11 months

Product dosage points in a mill decides the efficient VFA reduction in the final paper. Identifying the right anaerobic pockets & applying proper dosages is one of the optimization parameters during the initial optimization at any mill.

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The results documented in figure No. 4 depicts the VFA variations along with the change in dosing point.

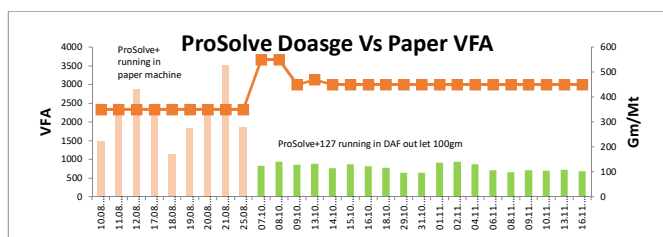


Figure No. 4: Paper VFA Vs ProSolve+ dosages

The presented study showed that the change in the dosing from the machine parts to the DAF outlet has resulted in decreased VFA numbers by 1000ppm.

3. Slime Reduction on the machine parts

Slim is one of the key issues in a recycled paper plant. The closed loop water system in recycled paper mills leads to an increased concentration of nutrients. This results in a huge build-up of bacterial population. Over a period of time, these microbes build a biofilm matrix of extracellular polymeric substances (EPS)8. This acts as a protective layer under which the anaerobic microbes grow fast. These pockets are mainly anaerobic (as the layer creates anaerobic conditions) and facilitates the growth of the pathogenic bacteria. Bio-films are difficult to penetrate by hypo / biocides and hence these colonies end up as slime at various machine parts in the paper mill. The figure No. 5 shows the biofilm formation in a mill.



Figure No. 5: Slim layer formation on the inner side of machine parts (Before 'ProSolve+')

The dual formulation contains both the bio-dispersant & consortium of probiotic microorganisms and works in two ways. Firstly, the active bio-dispersant part of the formulation helps in penetrating into the inner parts of the machine where general biocidal chemicals cannot reach and effectively destroys the biofilm or the slime layer. While the consortium of probiotic and beneficial microbes inhibits pathogenic bacteria by a process of competitive exclusion in this zone, thus preventing slime from accumulating. The figure No. 6 shows the cleaned machine parts after applying 'Probiotic Odour Control' program in the mill system. In conclusion it not only reduced the downtime for cleaning but also increased the overall runnability of the mill.



Figure No. 6: Slim layer reduction on the inner side of machine parts (after 'ProSolve+')

- Exopolysaccharides as Antimicrobial Agents: Mechanism and Spectrum of Activity, Abdelmoneim K. Abdalla, Mutamed M. Ayyash, Amin N. Olaimat, Tareq M. Osaili, Anas A. Al-Nabulsi, Nagendra P. Shah and Richard Holley, 2021
- Relationship between Oxidation Reduction Potential (ORP) and Volatile Fatty Acid (VFA) Production in the Acid-Phase Anaerobic Digestion Process, Thesis, Sung Jae Lee, January 2008
- 8 - Microbiologically influenced corrosion (MIC), JuditTelegdi, m AbdulShaban, LaszloTrif, 2017, 191-214
- Sulfur reducing bacteria an Overview, Advances in agronomy, 2013.
- Water quality, hygiene, and health, OmidBozorg-Haddad Mohammad Delpasand, Hugo A.Loáiciga, Economical, Political, and Social issues in Water Resources, Book Chapter, 2021, 217-257
- Microbial Extracellular Polymeric Substances: Ecological Function and Impact on Soil Aggregation, Ohana Y. A. Costa, Jos M. Raaijmakers and Eiko E. Kuramae, 2018, Frontiers in Microbiology.

Benefits of 'Probiotics'

1. Operational:

- Substantial reduction of slime deposits due to breaking down of biofilms
- Reduced shut down, increased runnability, & better productivity
- Lower maintenance costs & better profits
- Elimination of Hypo & Biocide helps in prevention of scaling & corrosion

2. Paper Quality:

- Cleaner Paper: Bio-dispersant prevents agglomeration of starch and nutrients which end up as deposits on paper
- Reduced/No Odor: Probiotic microbes help in elimination of H₂S and reduction in VFA which result in odor control
- Chlorine Free: Complete elimination of Hypo aids in producing chlorine free paper
- Lower VFA: Probiotic microbes inhibit pathogenic microbes which are the principal cause of VFA

3. ETP & Environment:

- Lower COD & TDS: Total elimination of hypo and biocide help in reduction of COD & TDS
- Improved ORP: Reduction in organic load helps in improved dissolved oxygen levels
- Odor free Environment: Elimination of H₂S and other volatile organics enable an odor free environment

Conclusion

ProKlean's extensive research & studies around probiotics and biosurfactant has led to the development of the product 'ProCharta ProSolve+' as an efficient odour control program for the recycled kraft paper industry. It is a sustainable & biodegradable solution for the recycled paper industry to get rid of the odour issues from environment & produce a good quality of paper in natural way. It is an attempt to push the paper industry towards cleaner & greener processes by improving their water conditions & hence environment. Probiotics are known for their good effects not only for the well-being of human beings but also for the environment wherever pathogens are the issue. Water is always one of the important elements on the earth and any attempt towards making it more acceptable & recyclable will be an effort towards making the mother earth greener & cleaner. 'Probiotic Odour Control Program' is definitely a promising solution for recycled paper industry to make it a better place to work.

References

- Production of Organic Acids by Probiotic Lactobacilli Can Be Used to Reduce Pathogen Load in Poultry, Jason M. Neal-McKinney, Xiaonan Lu, Tri Duong, Charles L. Larson, Douglas R. Call, Devendra H. Shah, and Michael E. Konkel, 2012, 7(9)
- Exopolysaccharides from probiotic bacteria and their health potential J. Angelin and M. Kavitha, 2020, 162: 853-865