MICROBIAL DEGRADATION AND NUTRIENT OPTIMIZATION OF PULP AND PAPER INDUSTRY WASTE WATER.

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Abstract - *Microbial degradation is an effective method for the treatment of the effluents from pulp and paper mill.The sample was inoculated with bacterial and fungal species and their efficiencies were compared for nutrient optimization. Species selected were Rhizopus sp and Bacillus subtilis . BOD reduces from second to tenth day by 90.4% by fungal treatment and 87.6% by bacterial treatment. COD reduces from second to tenth day by 90.2% by fungal treatment and 88.6% by bacterial treatment. Maximum reduction is seen at 0.5% concentration of nutrients for fungal treatment .The maximum reduction is seen at 1 % concentration of nutrients for bacterial treatment. Fungus is more efficient in reducing the lignin derivatives which is the cause for presence of brown colour in effluent.*

***Key Words*: Pulp and paper industry, waste water,microbial degradation**

1. INTRODUCTION

Pulp and paper mill is one of India's core sector industries contributing to large quantity of industrial water pollution. The waste water is produced from wood preparation, pulping process, pulp washing, screening, washing, bleaching and machine cleaning operations [7].The paper mill waste water is characterised by brown colour, high quantities of pH, Total Dissolved Solids(TDS), Suspended Solids (SS) Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD).The high BOD and COD is due to organics like lignin, cellulose, fatty acids, tannins, resins, chlorinated organic compounds and inorganic like sodium, calcium, silicates, mud, grit sulphur compounds etc. Some of these compounds have the capacity to bio accumulate in the aquatic food chain [5].The introduction of contaminants through effluent and sludge to different environmental compartments can often overwhelm the self cleansing capacity of recipient ecosystems and result in accumulation of pollutants[6].

Waste water contains high concentration of lignin and COD which is harmful to the environment. Biological treatment is more preferred which has no negative impact on the environment .The objective of the study is to optimize the nutrient content required for degrading the effluent. Study was also done to find the efficiency of fungus and bacteria in reducing the colour, BOD and COD of the effluent and to compare them.

Microbial degradation is an effective method for biological treatment of the effluent. Both bacteria and fungi are capable of degrading pulp and paper industry waste water [3] conducted. Immobilization technique with fungus helps in decolourization and significant reduction of BOD, COD and lignin [2].Decolourization can be considered an indicator for detoxification of the effluent [1].

2. MATERIALS AND METHODS

2.1 Sample preparation

The sample was collected from pulp and paper mill at Kumaloor, Kollam. The samples were collected in the plastic container and were brought to the laboratory and immediately stored in refrigerator at 4°C until used for further analysis [4]. The collected sample was analyzed for various physico- chemical characteristics as per standard methods for the examination of water and waste water. The various physico- chemical parameters analyzed include pH, Turbidity, BOD, COD, etc. A fungal species and bacterial species were used for the treatment.

2.2Media Preparation

Potato Dextrose Agar (PDA) medium and Potato Dextrose Broth (PDB) medium were prepared for culture of fungus. Nutrient agar and nutrient broth were prepared for culture of bacteria. PDA medium is prepared by mixing 20g dextrose, 4 g potato extract and 15 g of agar in 1000ml distilled water. The pH of medium is adjusted in the range of 5.5- 6.5. PDB medium is prepared by boiling 200g of potato in 1000ml distilled water and the remaining filtered water is mixed with 20g glucose. The pH of medium is adjusted to 5.6. Nutrient agar is prepared from 0.5% Peptone, 1.5% agar, 0.5% NaCl and distilled water. The composition of nutrient broth consists of peptone, NaCl and distilled water.

2.3 Microorganism

The species selected for treatment were *Rhizopus sp.* and *Bacilus subtilis.* Bacterial species was collected from Microbial Culture Centre, Pune. Fungal species was collected from Microbiology Lab of College of Engineering Trivandrum.

2.4 Treatment

The species selected for treatment were *Rhizopus sp.* and *Bacilus subtilis* .PDA medium and PDB medium for culture of fungus was prepared .Nutrient agar and nutrient broth for culture of bacteria was prepared .Cultures were prepared on agar slants and transferred to broth for culturing them in waste water sample.

A batch set up was done for treating the waste water sample. Collected sample were taken in conical flasks and analysed.Then it was supplemented with nutrients to improve the efficiency of the microorganisms. The nutrients used are glucose and NH_4Cl which are supplemented at concentration ranging from 0.25%-1%. Then it was treated using both fungal and bacterial species individually. Analysis was done after 2,4,6,8 and 10^{th} day for both BOD and COD. Variation in colour was determined by finding the variation in absorbance using spectrophotometer.

Fig-1 Slant prepared for bacterial culture and fungal culture

Fig-2 Batch setup

3. RESULTS AND DISCUSSION

The effluent was collected and analyzed as per standard methods of analysis of water and wastewater. The characterization studies were conducted for pH, turbidity, colour, BOD and COD. Table 1 shows the results of the analysis of the samples.

From the study it is observed that the effluent is highly coloured. The values of BOD, COD were very high as compared to CPCB limits for discharge into inland surface water. The dark brown colour reduces the DO content and sunlight which affects aquatic life. These compounds are not easily degraded naturally which demands the use of various fungal, bacterial, algal species and enzymes for the effective removal of colour, turbidity, COD and BOD.

Table -3.1: characteristics study of effluent

Sl.no	Parameter	Values	Tolerance limit for discharge into inland surface water(CPCB 2012)
1	pH	7.31	5.5-9
2	Colour	brown	Colourless
3	Turbidity(NTU)	100	5
4	BOD(mg/L)	1110	30
5	COD(mg/L)	12800	250

3.1 BOD and COD reduction

Table- 3.2: Variation in BOD with fungal treatment

TIME	BOD(mg/L)		
	1% nutrient	0.5% nutrient	0.25% nutrient
2 nd day	760	620	820
4 th day	595.5	535	696.6
6 th day	356	254	408.9
8 th day	200	98.86	127.8
10 th day	98	52.4	60

Table -3.3: Variation in COD with fungal treatment

TIME	COD(mg/L)		
	1% nutrient	0.5% nutrient	0.25% nutrient
2 nd day	8697	9025	10000
4 th day	6020	7557	8967
6 th day	4500	5940	6567
8 th day	2105	2589	3700
10 th day	987	1200	2000

Table- 3.4: Variation in BOD with bacterial treatment

TIME	BOD(mg/L)		
	1% nutrient	0.5% nutrient	0.25% nutrient
2 nd day	730	761	870
4 th day	500	540.4	668
6 th day	256.681	312	400
8 th day	97.3	112	150
10 th day	86	94	112.9

Table- 3.5: Variation in COD with bacterial treatment

TIME	COD(mg/L)		
	1% nutrient	0.5% nutrient	0.25% nutrient
2 nd day	8500	7156	9200
4 th day	6025	5985	7560
6 th day	4758	3250	400
8 th day	1850	1207	2750
10 th day	950	700	1000

The tables 3.2 and 3.3 show the reduction in BOD and COD after fungal treatment. The tables 3.4 and 3.5 shows the reduction in BOD and COD after and bacterial treatment .The results obtained after treatment with the fungal and bacterial species showed reduction in BOD, COD and colour.

COD reduces from second to tenth day by 90.2% by fungal treatment and 88.6% by bacterial treatment. The reduction in COD is more when the sample is supplemented with 0.5% nutrients and inoculated with fungal species. But for sample inoculated with bacterial species the reduction is more when the sample is supplemented with 1% nutrients. BOD reduction also occurs after treatment with both bacteria and fungus.BOD reduces from second to tenth day by 90.4% by fungal treatment and 87.6% by bacterial treatment. The reduction in BOD is more when the sample is supplemented with 0.5% nutrients and inoculated with fungal species. But for sample inoculated with bacterial species the reduction is more when the sample is supplemented with 1% nutrients.

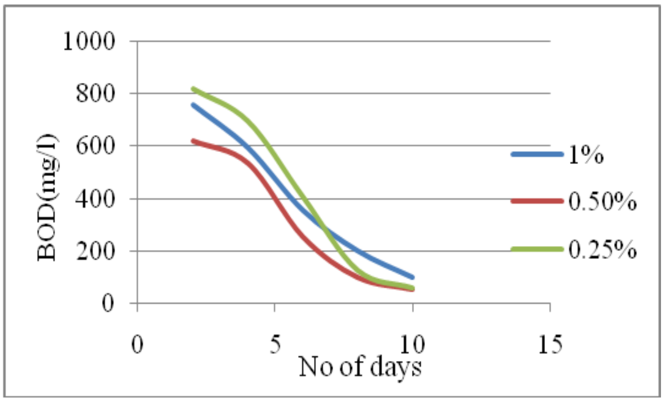

Fig -3.1: Variation in BOD after fungal treatment with different nutrient concentration

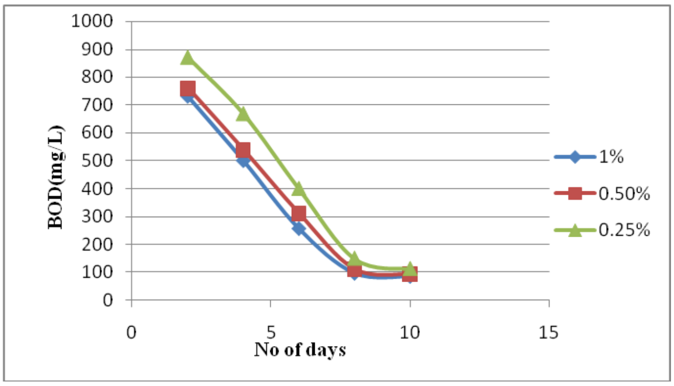

Fig -3.2: Variation in BOD after bacterial treatment with different nutrient concentration

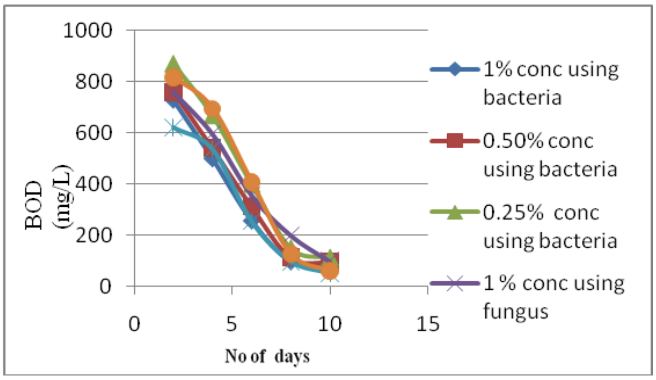

Fig-3.3: Comparison between variations in BOD with fungal and bacterial treatment

The figure 3.1 shows the variation in BOD while treating with fungal species. The reduction is more when the effluent is supplemented with0.5% concentration of nutrients. The figure 3.2 shows the variation in BOD while treating with bacterial species. The reduction is more when the effluent is supplemented with 1% concentration of nutrients. The figure 3.3 shows comparison between variations in BOD with fungal and bacterial treatment. By comparing the values it is seen that fungus is more capable of reducing BOD compared to bacterial species. This is due to increasing reduction of lignin derivatives and organic matter by fungal species.

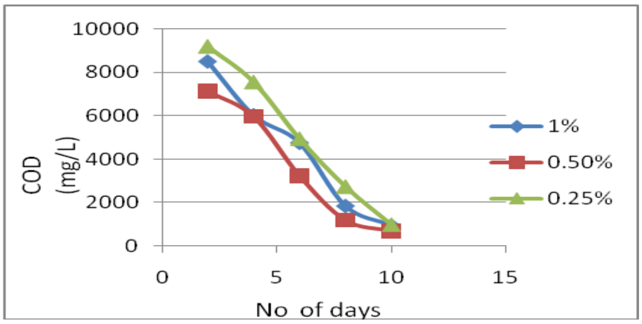

Fig-3.4: Variation in COD after fungal treatment with different nutrient concentration

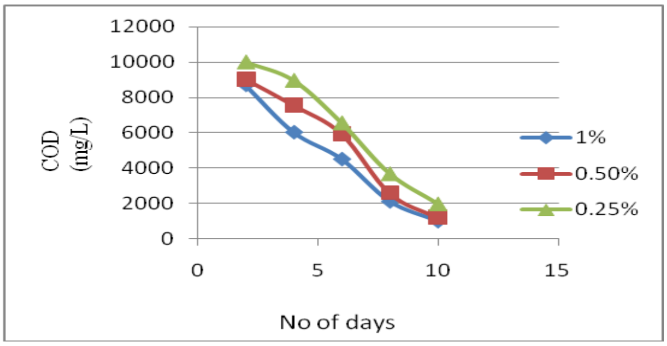

Fig-3.5: Variation in COD after bacterial treatment with different nutrient concentration

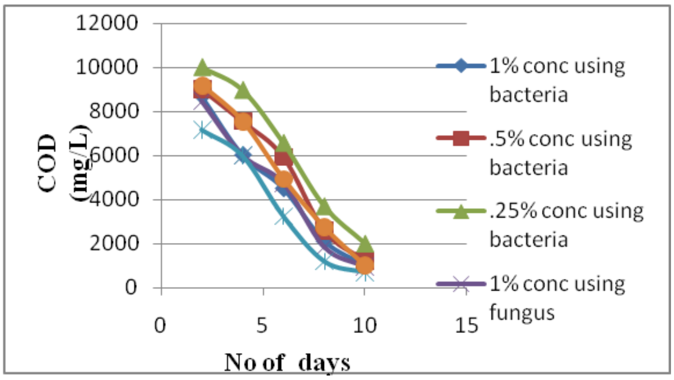

Fig-3.6: Comparison between variations in COD with fungal and bacterial treatment

The figure 3.4 shows the variation in COD while treating with fungal species. The reduction is more when the effluent is supplemented with0.5% concentration of nutrients. The figure 3.5 shows the variation in COD while treating with bacterial species. The reduction is more when the effluent is supplemented with 1% concentration of nutrients. The figure 3.6 shows comparison between variations in COD with fungal and bacterial treatment. By comparing the values it is seen that fungus is more capable of reducing COD compared to bacterial species. This is due to efficient reduction of lignin derivatives and high molecular weight compounds by fungal species.

3.2 Colour

Reduction in absorbance occurs with bacterial and fungal treatment. Absorbance reduces from first day to tenth day by 73%by fungal treatment and 67.46% for bacterial treatment. Maximum reduction is seen at 0.5% concentration of nutrients for fungal treatment. The maximum reduction is seen at 1 % concentration of nutrients for bacterial treatment. The presence of brown colour in the effluent is mainly due to lignin derivatives Fungus is more efficient in reducing these lignin derivatives so it shows better colour reduction.

4. CONCLUSIONS

Pulp and paper mill effluent contains harmful chemicals, lignin and if discharged untreated into the surface water bodies or land cause serious environmental damages. The physical and chemical methods used for the treatment of the pulp and paper mill effluent are not economic and not very efficient in reducing lignin. So biological methods are more preferred. Microorganisms like fungi, bacteria etc can be used for treatment.

In the present study the effluent was treated with a bacterial species as well as fungal species. The samples were also supplemented with Glucose and NH_4Cl at 1%, 0.5% and

0.25% concentration. The average COD reduction is 90.2% by fungal treatment and 88.65% by bacterial treatment. The average BOD reduction is 90.4% by fungal treatment and 87.6% by bacterial treatment. Colour reduction is 73%by fungal treatment and 67.46% reduction for bacterial treatment.

Addition of nutrients has enhanced the rate of reduction of BOD, COD and colour. Optimum nutrient concentration for fungal species is 0.5% and bacterial sp is 1% as they show maximum reduction when supplemented with the nutrients at the mentioned percentages. Compared to bacterial species, the fungal species is more effective in reducing BOD, COD and colour. Fungus has the capacity to degrade lignin derivatives and organic matter much efficiently compared to bacteria.

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