Bioremediation of Waste Water from Natural Rubber Processing Plant

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Abstract – *Rubber industry is an agro-based industry, feeding many other industries. It consumes large volume of water during different stages of production, uses many chemicals and produce huge amount of effluent. The discharge of this effluent without proper treatment into water bodies can deteriorate the water bodies and can affect human and aquatic life adversely. In search for better treatment options bioremediation is a suitable option. Three bacterial species were identified and isolated from rubber effluent- Pseudomonas sp., Bacillus sp., and Lactobacillus sp. These bacteria and also the bacterial consortium containing equal proportion of these bacteria were used in the treatment of rubber effluent. They were tested for its efficiency on the bioremediation of rubber processing effluent. Efficiency is determined on the basis of study of physico-chemical properties such as pH, BOD, COD, TS, and ammonia. Treatment period of 15 days was used in the study and determination of physico-chemical properties were done at an interval of 5 days during this period. Based on the results obtained after the completion of treatment, it was concluded that the bacterial consortium shows better efficiency than the individual bacterial species. Among individual species Pseudomonas sp. showed maximum efficiency and Lactobacillus sp. showed least efficiency.*

Key Words: Natural rubber industry, Natural rubber latex, Source of effluent, Environment, Bioremediation.

1. INTRODUCTION

The availability of water both in terms of quality and quantity is essential for the very existence of life on earth. Water pollution is causing much of the available water unsafe for consumption. In India, most of the population is dependent on surface water as the only source of drinking water supply. The contribution of effluents from agricultural and agro-based industries to pollution is huge in major agricultural countries of the world. The amount and composition of industrial effluent are determined by the nature of the products and treatment process. Unlike other industries, agro-based industries generate enormous solid and liquid wastes of carbonaceous and nitrogenous origin.

Natural rubber industry is an agro-based industry and feeding many other industries with its outputs. A few of the beneficiary industries to name are the automobile, foot-ware and construction industries. Since the production of rubber products from natural rubber needs large amount of water for its operation, the rapid growth of rubber industries has produced large quantities of effluent from this processing. Wastewater discharged from latex rubber processing usually contains high level of BOD, COD and SS. The main source of pollutants is the coagulated serum, field latex coagulation and skim latex coagulation. These compounds are readily biodegradable and will result in high oxygen consumption upon discharge of wastewater in receiving surface water. The effluent is also acidic in nature. Another serious threat of rubber wastewater is high concentration of ammonia in the effluent. It contributes to undesirable eutrophication.

Destruction of the environment would ultimately result in the depletion of life on earth. Therefore pollution reduction, environmental protection and conservation of the environment are very important for a healthy life in the future. Addressing these problems requires identification of new methods of purifying water at lower cost and with less energy, while at the same time minimizing the use of chemicals and the impact on the environment.

Bioremediation is a popular and attractive technology that uses the metabolic potential of microorganisms to clean up the environment. This project involves the study of treatment of effluent from rubber processing industries using three species of microorganisms and microbial consortium. Microbial sp. used in the study are *Pseudomonas* sp., *Lactobacillus* sp. and *Bacillus* sp. They are identified from the rubber effluent and cultured in the laboratory. The present study compares the efficiency of *Pseudomonas* sp., *Bacillus* sp., *Lactobacillus* sp., and bacterial consortium consisting of these three bacteria in treating the rubber effluent.

2. METHODOLOGY

2.1 Sample Collection

The sample was collected from Mukkam Latex, a latex processing industry at Mukkam, Kozhikode. The sample was collected in sterile plastic container rinsed with the sample. The sample was taken in two turns. Sample taken in the first go was used for biochemical studies and identification and culturing of microbes. Sample taken in the second time is used for initial characteristic determination and for bioremediation study. The sample used for DO determination was collected in BOD bottle and added few drops of manganous sulphate solution to fix the dissolved oxygen.

2.2 Bacterial Culture Preparation

Both streak plate method and spread plate method were done during the project for obtaining discrete colonies from mixed culture. Once discrete, well separated colonies develop on the surface of a nutrient agar plate culture, each may be picked up with a sterile needle and transferred to separate nutrient agar slant. A total of seven discrete colonies were found. Each of these seven slant culture represents the growth of a single bacterial species and is designated as pure or stock culture. The slants are labelled and incubated at 37^{o} C for 18 to 24 hours. These stock cultures were used in the identification studies to identify the bacterial species. Characteristics such as morphology, staining reaction, biochemical characteristics of culture in each slant were studied and the results are tabulated and microbes identified. The pure culture of required microorganisms thus obtained is used for determination of optical density and acclimatization. The bacterial cultures selected for the study are *Pseudomonas* sp, *Bacillus* sp, *Lactobacillus* sp. The bacterial consortium contains equal proportion of these three cultures. The optical density of sample is measured at wavelength of 600 nm. The acclimatization of bacteria was done by growing it in minimal organic salt medium amended with 10 % of the rubber processing effluent.

2.3 Experimental Setup

The experimental set up consists of a reactor of size 10 cm X 10 cm X 50 cm. The aerator was used to maintain the aerobic condition in the treatment process so as to support the proper growth of aerobic microorganisms in the tank. Reactors were washed with ethanol to make it sterile and then rinsed with distilled water. The waste water and 1 % of each microbial culture was introduced into the reactors. The top portions of reactor were covered using aluminium foil to prevent contamination. The sample is taken at an interval of 5 days for testing parameters such as pH, BOD, COD, TS and ammonia. The degradation efficiency of *Pseudomonas* sp, *Bacillus* sp, *Lactobacillus* sp, and bacterial consortium was thus determined. And the efficiencies are compared with that of control reactor.

Fig -1: Experimental Setup

3. RESULTS AND DISCUSSION

The table below shows the characteristics of rubber effluent before it is treated.

Table -2: Characteristics of effluent before treatment

Parameter	Value obtained
pH	4.6
BOD (mg/L)	4320
COD (mg/L)	10800
TS (mg/L)	11700
Ammonia (mg/L)	989

3.1 Optical Density

Optical densities of bacterial cultures were found and the obtained values are listed below:

Table -3: Optical density values obtained for bacterial culture

Bacterial species	Optical density
Pseudomonas sp.	1.79
Bacillus sp.	1.34
Lactobacillus sp.	1.15
Bacterial consortium	1.22

3.2 Characteristics of Effluent after Treatment

The pH of the untreated waste water was acidic. After treatment the pH was observed to be neutral to near alkaline. The pH normally rises upon treatment. In the control reactor the pH has reduced from 4.6 to 6.5 whereas in reactors inoculated with *Pseudomonas* sp., *Bacillus* sp., *Lactobacillus* sp, and bacterial consortium the pH has reduced to 7.9, 8.3, 8.2, and 8.7 respectively. Comparison of pH values obtained after is shown in the chart 1.

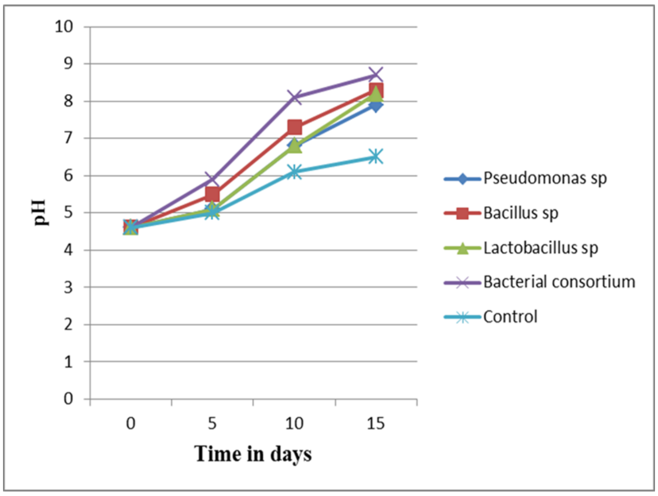

Chart -1: Comparison of pH values obtained after treatment

Biochemical Oxygen Demand test constitutes the most important test for the waste waters. The permissible limit of BOD value for discharge of waste into inland surface water is 30 mg/L (BOD_3). BOD removal efficiencies of *Pseudomonas* sp., *Bacillus* sp., *Lactobacillus* sp., and bacterial consortium are 71.8 %, 65.7 %, 57 %, and 77.9 % respectively as compared to 34 % removal efficiency in control reactor. Bacterial consortium has maximum removal efficiency. The reduction in BOD could be associated with consumption of organic matter by microbes as a food source. Carbon source are required for the synthesis of new cellular material. Comparison of BOD values after treatment is shown in chart 2 and removal efficiency of BOD after treatment is shown in chart 3.

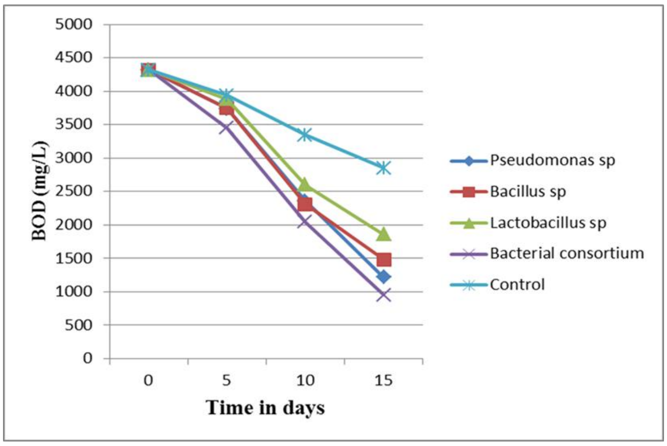

Chart -2: Comparison of BOD values obtained after treatment

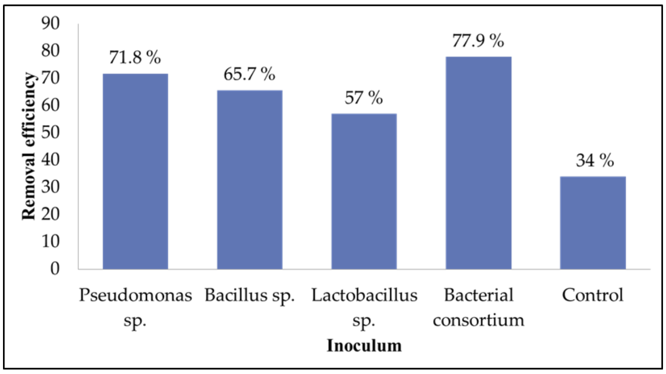

Chart -3: Removal efficiency of BOD after treatment

The rubber effluent has very high COD value before treatment. The permissible limit of COD value for discharge of waste into inland surface water is 250 mg/L. It is evident from the result that COD content of effluent was significantly reduced after treatment with microorganisms. The COD removal efficiencies of *Pseudomonas* sp., *Bacillus* sp., *Lactobacillus* sp., and bacterial consortium are 80.4 %, 78.6 %, 68.3 %, and 77.9 % respectively. Bacterial consortium showed maximum removal efficiencies while lactobacillus showed least removal efficiencies. The removal efficiency in control reactor is only 32.5 %. Comparison of COD values after treatment is shown in chart 4 and removal efficiency of COD after treatment is shown in chart 5.

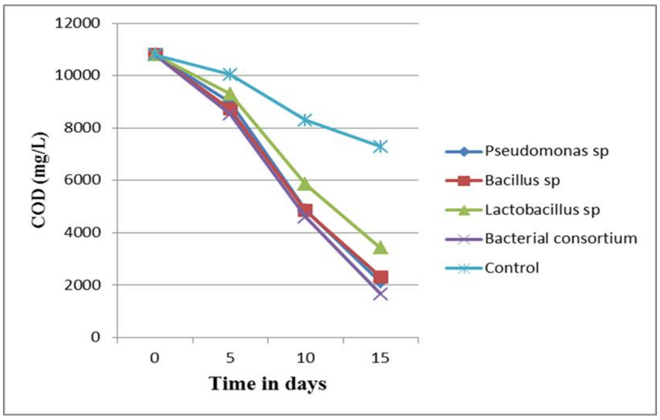

Chart -4: Comparison of COD values obtained after treatment

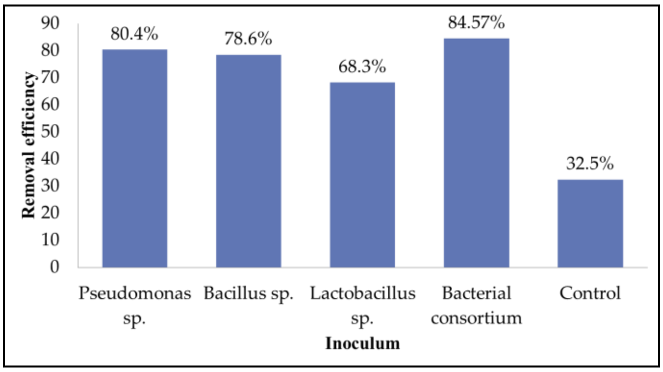

Chart -5: Removal efficiency of COD after treatment

The comparison of total solid content after treatment is shown in chart 6 and efficiency in removal of total solids is shown in chart 7. Reduction efficiency of 78.7 %, 75.2 %, 63.6 %, and 81.8 % respectively were shown by *Pseudomonas* sp., *Bacillus* sp., *Lactobacillus* sp., and bacterial consortium. A very low removal efficiency of 25% was only observed in the control reactor.

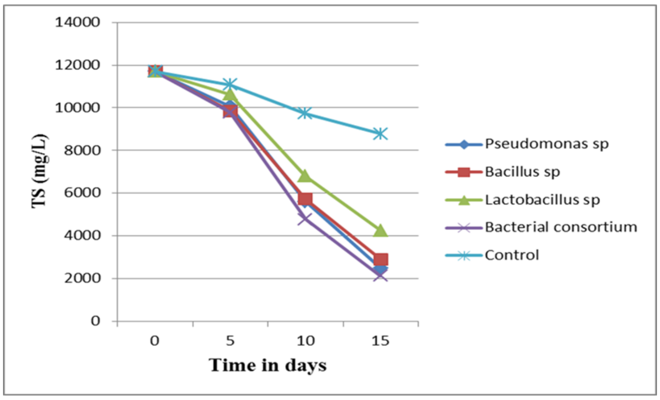

Chart -6: Comparison of total solid content after treatment

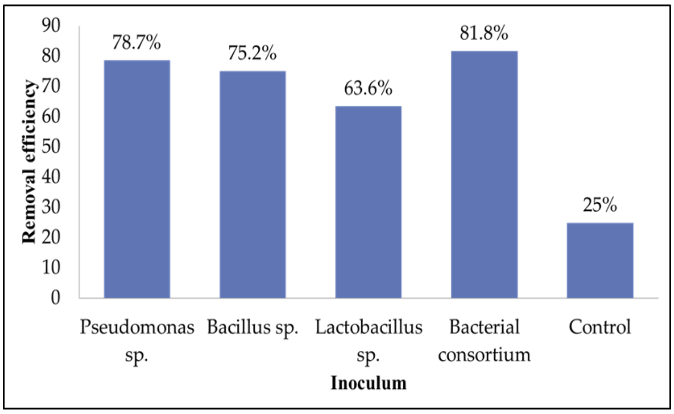

Chart -7: Removal efficiency of total solids after treatment

Due to the use of ammonia compound during the processing of natural rubber ammonia level in rubber effluent is very high. High concentration of ammonia adversely affect aquatic environment and can cause eutrophication. The permissible limit of ammonia for discharge of waste water to inland surface water is 50 mg/L. There is a significant reduction of ammonia content during the treatment. The removal efficiencies shown by *Pseudomonas* sp., *Bacillus* sp., *Lactobacillus* sp., bacterial consortium and control were 77 %, 73.5 %, 62.7 %, 79.3 % and 51.9 % respectively. Microorganisms during the oxidation of organic material to simple end products require nutrients (inorganic elements) which it obtains from ammonia, phosphate etc. Comparison of ammonia value after treatment is shown in chart 8 and comparison of removal efficiencies of ammonia after treatment is shown in chart 9.

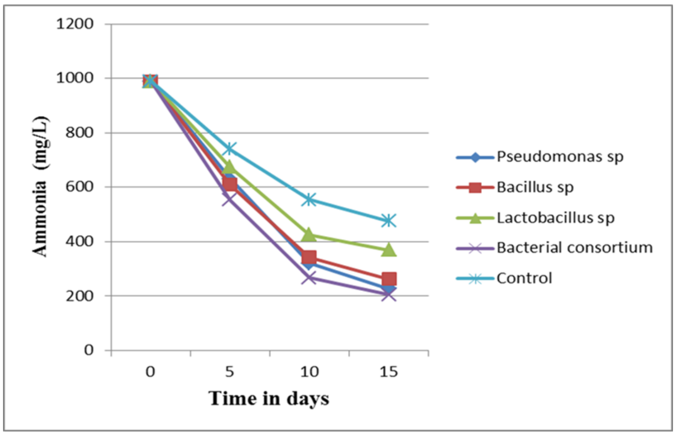

Chart -8: Comparison of ammonia values obtained after treatment

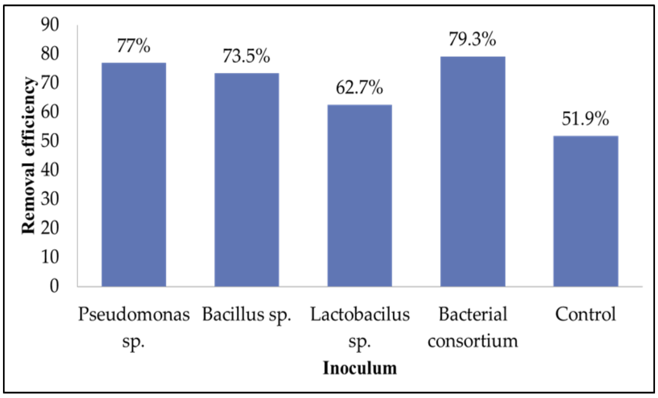

Chart -9: Removal efficiency of ammonia after treatment

4. CONCLUSION

In the present study it was observed that bioremediation of rubber effluent significantly reduced the pollutant level in a retention period of 15 days. Bacterial consortium is observed to be more effective in reduction of pollutant level while removal efficiency *Lactobacillus* sp. was the least. After treatment with bacterial consortium for 15 days BOD and COD reduction were 77.9 % and 84.57 % respectively. In comparison to initial levels, both COD and BOD reduced significantly indicating the decrease in the pollutant level. Treatment with bacterial consortium also yielded substantial reduction in the total solids (81.8 %) and ammonia (79.3 %). The pH of the effluent changed from acidic to alkaline resulting in reduction of acidity of the effluent. Bacterial consortium is efficient as compared to single species of microorganisms.

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