TERTIARY STAGE BACTERIAL TREATMENT OF PULP PAPER MILL EFFLUENT BY USING AXENIC AND MIXED CULTURES IN A BATCH REACTOR

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ABSTRACT

Pulp and paper mill effluent (PPME) continues to pose a serious environmental burden due to the persistence of organic pollutant seven after conventional treatment. This study investigates tertiary-stage bioremediation approach using specific axenic and mixed bacterial cultures in a batch reactor. Three bacterial strains—*Pseudochrobactrum glaciale* (IITRP1), *Providencia rettgeri* (IITRP2), and *Pantoea* sp. (RCT2)—were applied to biologically treat pre-treated PPME over a 168-hour incubation period. The mixed bacterial consortium demonstrated the most notable efficacy, achieving 56% decolorization. Substantial reductions were also recorded in key water quality indicators: chemical oxygen demand by 77%, biological oxygen demand by 86%, lignin by 91%, pentachlorophenol (PCP)by 94%, and total phenols by 96%. These findings suggest that bioaugmentation using mixed bacterial cultures can serve as a sustainable and cost-efficient solution for enhancing the treatment of industrial effluents at the tertiary stage.

Keywords: Pulp and paper mill effluent, Tertiary wastewater treatment, Bioremediation, Mixed bacterial cultures, Decolorization, Environmental sustainability

1. INTRODUCTION

Pulp and paper mill effluents are recognized as major sources of environmental pollution, as reported by the USEPA (1998). If discharged without proper treatment, these effluents can severely deteriorate the quality of receiving water bodies, mainly due to their strong color and high pollutant load. They typically contain elevated levels of biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Additionally, these effluents include chlorinated compounds, absorbable organic halides (AOX), suspended solids such as fibers, fatty acids, tannins, resin acids, sulfates, phenolic compounds, heavy metals, and lignin along with its derivatives [1,2].

To prevent environmental harm, pulp and paper mill effluent (PPME) with these characteristics must be properly treated prior to being released into water bodies. One persistent issue is the dark black- brown color of the effluent, primarily resulting from lignin and its by-products released during the pulping, bleaching, and chemical recovery processes. Bleaching processes lead to the formation of chromophoric, highly oxidized polymeric lignin and chlorolignin derivatives, which contribute to the dark coloration of the effluent**.** Although a range of physico-chemical methods, such as mechanically cleaned circular clarifiers, membrane filtration, ozonation, chemical recovery, lime treatment, and activated carbon, can effectively lower BOD, total suspended solids (TSS), and toxicity, they are not as efficient at eliminating color-causing compounds and pentachlorophenols (PCP) [3,4].

Industries commonly utilize a sequence of treatment technologies across primary and secondary stages of wastewater processing. The primary stage involves physical methods aimed at removing larger suspended particles from the wastewater, while the secondary stage typically employs biological processes such as the activated sludge method to further purify the effluent. Despite these efforts, effluents often retain residual pollutants that can pose environmental risks. Consequently, implementing tertiary treatment becomes essential, particularly for wastewater from pulp and paper mills. Given the significant environmental damage caused by persistent and toxic chemicals—