UGC MAJOR RESEARCH PROJECT

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FINAL REPORT

"BIOFILTER FOR TREATMENT OF VOLATILE ORGANIC COMPOUNDS (VOCS)"

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Biofilter for treatment of Volatile Organic Compounds (VOCs)

Objective of the project:

The main focus of this research work is to degrade toluene and trichloroethylene using mixed culture derived from compost.

Cow dung and turkey litter compost consists of microorganisms and macroorganisms which are used to take advantage of changing temperature, moisture, oxygen content and pH. These also contain nutrients such as nitrogen, phosphorus and potassium which are essential for the microbial growth. Toluene and trichloroethylene commonly used as a solvent in process industry is taken as a model pollutant and tested for removal in batch and continuous mode using mixed culture from cow dung and turkey litter compost respectively. To determine the removal efficiency and elimination capacity of pollutants using acclimatized mixed cultures in a batch biodegradation and continuous biofilration. Biochemical characterization was carried out to identify the dominant species of microorganism accumulate in the mixed cultures. The performance evaluation and transient state behavior of biofilter in treating toluene and trichloroethylene were evaluated. Theoretical prediction of biofilter performance using mathematical model has been developed.

ACHIVEMENTS FROM THE PROJECT:

In this project work mixed culture from cow dung and turkey litter compost may be a alternative source for the microorganisms and it degrades the toxic volatile organic compounds of toluene and trichloroethylene. Composts mediated packing material of biofilter was successfully treat the contaminants. *Pseudomonas species* and *Pseudomonas guguanensis* are the predominating degrading strain in the composts for toluene and TCE with their metabolites. The biofilter experimental findings of this research work could explain the TCE bio-removal was enhanced by the use of toluene degraded culture in biofilter. Furthermore, the effect of operating parameters was studied. Contaminant

treated biofilter was modeled by kinetic expressions. Finally, the novel strains will be successful for the bioremediation of environmental pollutants.

SUMMARY OF THE FINDINGS:

The biodegradation potential of acclimatized mixed culture to utilize toluene was tested in batch experiments at initial concentrations ranging from 50 to 500 mg l^{-1}. The cultures were able to grow well in toluene, which is used as the sole carbon source at the concentration range studied, despite the prevalence of inhibition at a high concentration level of substrate. The maximum specific growth rate was 0.062 h^{-1}. The mixed cultures exhibited substrate inhibition at 100 mg l^{-1} of toluene. Biochemical characteristics were carried out and *Pseudomonas species, Bacillus species* and *Escherichia coli* were found to be predominant in mixed culture. The kinetic parameters were estimated from suitable substrate inhibition models. The corresponding values of experimental and model predicted values are tabulated and compared. It was found that the Levenspiel model was best fitted with the experimental data.

A batch experiment was carried out to assess the potential of turkey litter compost for biodegradation of trichloroethylene (TCE) up to 500 mg L^{-1} and their metabolites (DCAC, TCA and DCA). The biodegradation kinetics of TCE was modeled by Aiba substrate inhibition model and their metabolites were modeled by Monod model. Biodegradation rate and kinetic constants at different concentration for TCE and metabolites were estimated. The diversity of the mixed microbial culture involved in the TCE metabolism was identified by biochemical test kit and the strains are *Pseudomonas toyotomiensis (IS 1), Enterobacter aerogenes (IS 2) and Escherichia colli (IS 3)*. For further confirmation, the culture was verified by 16S rRNA sequencing method. The isolate of *Pseudomonas guguanensis* identified as a predominant strain in compost that is responsible for the degradation of TCE and their metabolites. This novel strain will be successful for the bioremediation of environmental pollutants.

Continuous removal studies are carried out in a compost biofilter for treating the toluene vapors that is showed the feasibleness of treating VOCs under extended periods of operation at different loading rates. The high removal efficiency of 97% was obtained

within the biofilter at an inlet load of 60.55 g m^{-3} h^{-1}. Hence, it was found that the biomass concentration is also the limiting factor at a higher load of toluene therefore it is affected the removal rates in the compost biofilter. The maximum elimination capacity of the biofilter carrying toluene was high as 93 m^{-3} h^{-1}at inlet loading rate of 114 g m^{-3} h^{-1}. Throughout the transient condition (shut down, restart and shock loading), this study has been provided a useful information on stability of the biofilter. Hence, the result reveals that the biofilter showed less sensitive upon changing the operating condition because a new steady state was achieved within 3–4 days after the restart and shock loading which was same attained before at initial, that is depends upon the inlet load reapplied to the system. An immediate reinstatement of biological activity after a few days of starvation that is indicated the biofilter's capability where handle intermittent situations which is frequent for industrial biofilters. Furthermore, a mathematical model was used to predict the theoretical elimination capacity and the average thickness of biolayer in the toluene biofilter was found to be 0.98 mm.

A biofilter column inoculated with *Pseudomonas species* and *Pseudomonas guguanensis* taken from toluene and TCE degraded batch culture. Biofilter was operated to study cometabolic biodegradation of trichloroethylene (TCE) gas. The novel packing material of bamboo with different sizes was used. The variations in the efficiency and capacity of TCE elimination was investigated with different inlet concentration and flow rate of TCE. It was concluded that the toluene degraded isolates were enhanced the TCE removal effectively without using any primary substrate. Especially, the metabolites of TCE also degraded well in the toluene degrading strain used in the biofilter which was confirmed by the measurement of pH.

CONTRIBUTION TO THE SOCIETY:

In this present investigation, the isolated novel strain has been proved to be more potent in degradation of toxic volatile organic compounds (Toluene and TCE). Biofiltration is the effective treatment operation for the removal of pollutants with low operating and maintaining cost from various contaminated site waste streams. Knowledge addition on the effective use of microbial source for pollutant degrading microorganisms is in the natural ecosystem which will help the society successful tool for the bioremediation of environmental pollutants.