9. Conclusion and Recommendation for Future Work

9.1. Conclusion

In the present research work,biodegradation of BTX,MTX and styrene in the biofilter packed with compost,woodcharcoal and woodcharcoal+compost modified composite beads wereperformed. The biofilterdemonstrated very good results even at higher loading rates without asupply of nutrients throughout the experimental operation.Phsicochemical characterization results indicated that the composite beads possess most of the favorable properties required for successful biofilter operation.Physico-chemical properties of the modified composite beads such as porosity, surface area, buffer capacity and water retention capacity were improved compared to base materials woodcharcoal and compost used in our present work after modification. No medium compaction and very little pressure drop were seen in the biofilter media throughout the experiment. Bed temperature was always found more than inlet stream temperature indicating exothermic biochemical reaction in the biofilter. The following specific conclusions may be drawn on the basis of the results

1. The compost based modified biofilter was operated successfully under different loading condition of BTX for 57 days without supply of nutrient and during the operationno deterioration in the media was observed. The operation in the biofilter was stabilized after 18 days of operation which was evident from constant Removal Efficiency (RE) in the biofilter. The biofilter achieved amaximum removal efficiency of 95.8% at an inlet load of 549 $gm^{-3}h^{-1}$.Maximum combined elimination capacity of 983.9 g $m^{-3}h^{-1}$ was obtained at a total BTX loading of1312.19 g $m^{-3}h^{-1}$. The maximum removal efficiencies of the individual components i.e. benzene, toluene and xylene were found to be 96.80, 97.50 and 94.50% respectively. The maximum elimination capacities of the individual components i.e.

benzene, toluene and xylene were found to be 388.33, 327.73 and 276.84 g m^{-3} h^{-1} corresponding to inlet loading rates of 477.36, 439.02 and 376.65 g m^{-3} h^{-1} respectively. After attaining steady state almost constant RE of nearly 90% was observed upto individual loading rates of 331, 299.29 and 252.39 g m^{-3} h^{-1}. The value of EC_{max}using kinetic analysis was found to be 0.218, 0.255, 0.123 g $m^{-3}s^{-1}$(784.80, 918 and 442.8g $m^{-3}h^{-1)}$for benzene, toluene and xylene respectively. Similarly, the values of *K*s for BTX were found to be 1.72, 2.21, 0.79 g m^{-3} respectively. Using kinetic analysis the $EC_{max}$was found more than maximum elimination capacity obtained in the experiment which indicates further optimization of the biofilter is possible for more removal. The results show that the modified media is effective to degrade mixture of VOCs up to high loading rate without supply of nutrient. The operation was found sable and no significant deterioration of media was observed.

2. The wood charcoal based modified biofilter was operated successfully for 56 days without supply of nutrient. The modified media shows improvement in the desirable properties such as moisture retention capacity and bed porosity as compared to plain wood charcoal. During the whole operation no significantdeterioration in the media was observed. The woodcharcoal based modified biofilterachieved stable condition withinin 14 days andmaximum removal efficiency of 96.59 % for MTX at the concentration of 2.08 g m^{-3} on the18^{th} day of operation. The maximum elimination capacity was found to be 706.88 m^{-3} g h^{-1} at combined inlet loading of 972.33 m^{-3} g h^{-1} . More than 80% removal was obtained upto loading rate of 800 m^{-3} g h^{-1}. For individual components maximum removal efficiencies were found to be 96.35, 97.87 and 95.2% for MEK, toluene and xylene respectively. Similarly maximum elimination capacities of the individual components were

found to be 182.2, 313.39 and 232.96 at the loading rates of 229.43, 371.67 and 332.75 g $m^{-3}h^{-1}$whereasECmax obtained by kinetic analysis were found to be 0.13, 0.16, 0.099 m^{-3} g s^{-1} (468, 576 and 356.4 m^{-3} g h^{-1}) for methyl ethyl ketone, toluene and xylene respectively. Similarly, the value of *K*s was found to be 1.49, 1.71, 0.63 g m^{-3} respectively. Similar to compost based media, EC_{max}calculated using kinetic analysis the was found more than maximum elimination capacity obtained in the experiment which indicate further optimization of the biofilter is possible for more removal. The results clearly indicate that the biofilter packed with modified wood charcoal based media successfully degraded the pollutants upto very high loading rates.

3. The performance of compost based media in terms of removal efficiency and elimination capacities of combined mixture as well as individual components was slightly better than wood charcoal based media. The acclimation phase was over earlier in wood charcoal based media as compared to compost based modified media which is a good sign of quickness of media or formation of stable biofilm on the surface of media. In the kinetic analysis results the value of K_S for benzene and toluene was found lower in case of wood charcoal based media as compared to compost based media which is also indication of early acclimation of wood charcoal based media as compared to compost based media. The possible reason for quick behavior of wood charcoal based media may be good adsorption property of wood charcoal which is helpful in capture of pollutants from vapour phase and so enhance the rate of biofiltration.

4. On the basis of first two experiments it was observed that compost based media is better for removal of common VOCs in terms of removal efficiency and elimination capacity at high loading rates. To evaluate the efficacy of compost based media against a VOC which is

difficult degrade it was further tested against styrene for 121 days under different phases. The maximum removal efficiency of 98.2 % was obtained at the styrene loading of 520.2 g m^{-3} h^{-1}.Constant and more than 90% RE was obtained up to loading rate of 724 g m^{-3} h^{-1}. The maximum elimination capacity of 870.8 g m^{-3} h^{-1} was obtained at the styrene loading of 980.9 g m^{-3} h^{-1}.Michaelis-Menten kinetic constantsECmax and *K*s were also estimated and found to be1139.24 $gm^{-3}hr^{-1}$ and 1.77 g m^{-3} for styrene. High value of maximum elimination capacity calculated by model show there is still scope for further optimization to improve the performance of biofilter. Low variation of pressure drop across the bed, negligible change in pH of the leachate was found and also bed temperature was always found more than inlet stream temperature which indicative of heat of exothermicity in the biofilter.The result show that the compost based modified media is successful in degrading styrene upto high loading rate.

5. In the last experiment it was plan to evaluate the performance of compost and wood charcoal based composite modified biofilter media against styrene. The biofilteroperated without a supply of nutrients for 131 days under high loading conditions. SEM results indicated effective growth of biofilm on the surface of biofilter media.The results were almost similar to the compost based modified media with only exception of early acclimation of biofilter**.**In the case of compost based media steady state was achieved in 24 days whereas in case compost and wood charcoal based media, stable condition in the biofilter was establish within two week. This improvement in the result may be due to adsorption property of the wood charcoal. During the whole operation, a low variation of pressure drop across the bed, almost constant pH of the leachate and quick regain of the RE and EC after shutdown period was observed which indicated stable biofilm in the biofilter.

6. Over all compost and wood charcoalbased media has shown high removal and elimination of pollutants under varying and high loading conditions. When wood charcoal was mixed with compost and used as base material for preparation of modified biofilter media, significant decrease in the time required for acclimation was obtained.

9.2 Recommendation for future work

(i) In present work, a mixed bacterial culture obtained from the aeration unit of local wastewater plant was used to prepare the inoculum. In future pure culture can be used to biologically degrade the VOCs.

(ii) Physic-chemical characterization of the media like bed porosity, moisture retention capacity, dry weight, Carbon, Hydrogen and Nitrogen content were measured in this work.Other characterisation like Sulphur content,Oxygencontent,total metal content, BET surface area total pore volume of pores, average pore diameter etc. should also be reported.

(iii) Leachate characterization can also be done.

(iv) Analysis of the behavior of the microbial growth and VOC biodegradation kinetics should also be done in future work.

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