CHAPTER - 7.
Chapter 7.0 Executive Summary and Conclusions

The highlights of the present work are briefly summarized as follows.

1. Effluent from a Bulk drug industry from Solapur, India, manufacturing ephedrine from benzaldehyde using molasses as feedstock was characterized.

2. Its characteristics were found to be similar to distillery effluent, rich in organic matter and nutrients in addition to very high phenol contents.

3. Solapur is a big center manufacturing crude Indian cigarette called “Bidi”. It uses Tendu (*Diospyros melanoxylon*) leaves for wrapping tobacco. This process is performed as a home industry and the waste cutting of Tendu leaves are dumped nearby. This creates a solid waste disposal problem.

4. The solid waste of tendu cuttings was considered as biosorbent to adsorb organic matter and pollutants from the organic rich effluent.

5. The Chemical Oxygen Demand (COD) removal capacity of tendu leaves refuse was studied in a batch kinetic and adsorption isotherm experiments and compared with that of Granulated Activated Carbon.

6. Maximum COD removal was observed at a narrow pH range between 7 & 8.

7. The kinetic data fitted best in the pseudo-second-order chemisorption model. And the adsorption followed both Langmuir and Freundlich isotherms.

8. As per Langmuir model, maximum adsorption capacity was found to be 48.54 mg and 154.8 mg COD per g for tendu leaves refuse and GAC, respectively.
9. Tendu waste was further carbonized by sulfuric acid treatment. The carbonized tendu waste and raw tendu waste were studied for the removal of phenol from aqueous solution as a basic behavior in a mono-component system.

10. Batch kinetics and isotherm studies were carried out under varying experimental conditions of contact time, phenol concentration, adsorbent dose and pH.

11. Adsorption equilibrium of tendu leaves refuse and chemically carbonized tendu leaves refuse was reached within 2 hr for phenol concentration of 10-25 mg/L and 1 hr for phenol concentration of 20-200 mg/L, respectively.

12. The adsorption of phenol decreases with increasing the solution pH value. The kinetic data followed more closely the pseudo-second-order chemisorption model.

13. The adsorption data were modeled by using both Langmuir and Freundlich classical adsorption isotherms. The maximum adsorption capacity of chemically carbonized tendu leaves refuse was 31.3 mg phenol/gm, while that of raw TLR was 7.7 mg phenol/gm.

14. Scanning Electron Micrographs to study surface morphology of TLR, TLR-CM and TLR-CM (after phenol adsorption) at 10,000X magnification were obtained. Effect of chemical carbonization and subsequent phenol adsorption are clearly visible on the adsorbent surface.

15. The raw effluent from the molasses fermentation based bulk drug industry was treated exhaustively with raw tendu waste. About 89% phenol was removed during the treatment with 56% reduction in organic matter and 36% decrease in effluent volume.
16. The resultant treated effluent as well as raw effluent was subjected to seed germination bioassays using wheat and mungbean seeds.

17. A laboratory experiment to study the effect of different concentrations (0%, 10%, 25%, 50%, and 100%) of raw and treated effluents on germination index, fresh weight of leaves and chlorophyll contents in mungbean and wheat was carried out.

18. In a crop-specific response, mungbean showed enhanced growth up to 50% and 25% dilutions of treated effluent and raw effluent respectively. Whereas wheat exhibited good growth up to 25% and 10% dilutions of treated effluent and raw effluent respectively. Biosorption of phenols from raw effluent by tendu leaves refuse may have rendered the effluent acceptable for fertirrigation.

19. Organic enriched spent Tendu Leaves refuse obtained after exhaustive adsorption treatment of the effluent, was explored for soil amendment use.

20. Its fertilizer values was determined and used as a soil amendment on the growth of mungbean.

21. Total plant dry matter, chlorophyll, soluble proteins, peroxidase and superoxide dismutase were measured as indicators of phytotoxicity.

22. Total dry matter, chlorophyll and soluble protein levels did not show any significant change whereas statistically significant decrease in peroxidase activity and increase in superoxide dismutase at 200T/ha application level was observed.

23. The study shows that the spent biomass is well tolerated and can safely be used as soil amendment up to 100T/ha application level.
Potential advantages of the thesis outcome include:

- The use of tendu leaves refuse as biosorbent is being reported for the first time.
- The physico-chemical properties of the effluent from a bulk drug manufacturing unit based on molasses fermentation is also being reported for the first time.
- The basic adsorption properties of native and chemically carbonized tendu waste are quite comparable with that of other biomasses reported in the literature.
- Use of tendu waste for stripping of organic matter and phenols from effluent is cheaper as it is a solid waste disposal menace and available at zero cost.
- It can substitute costly activated carbon and save its regeneration process.
- Phenol adsorption from wastewater by chemically carbonized tendu waste is of value as it can facilitate further biomethanation treatment.
- The reduction in overall volume of effluent that remains after biosorption will require less dilution water for fertirrigation.
- The spent tendu leaves refuse biomass can be used as a biofertilizer and soil amendment. Such biomass can be stored, easily transported and dispensed as needed.
- The spent tendu leaves refuse biomass being in solid form, its soil application rates can be programmed based upon soil fertility, crop requirements, and chemical characteristics of the waste.
The biosorption treatment and reuse of entire tendu waste from Solapur city in a year can result in the savings of INR 4.44 million in term of chemical fertilizers.

An eco-friendly and viable option for two environmental problems has been addressed successfully.

The present study of tendu leaves waste for biosorption offers an economically feasible technology for efficient removal of pollutants, such as phenolics from wastewater. The recycling of organic wastes through their application to the soil can be an important, promising practice for agricultural activities, besides providing alternatives for reducing pollution.