CHAPTER 6

CONCLUSION

CONCLUSIONS AND FUTURE SCOPE OF WORK

The palm shell powder (PSP) used as an adsorbent in this study was found to have good adsorption capacity for cationic dyes but was found to be not effective for anionic dyes and pesticides. Acid Treated Palm shell Powder (APSP) used in this study was found to have good adsorption capacity for anionic dyes and pesticides. The study indicated that adsorption process depends upon initial pH, adsorbent dose, contact time and concentration.

Reactive dyes and anionic dyes were removed more effectively from solution by APSP at low pH. (pH-3 and 4 for reactive dyes and pH-1 for anionic dyes). As the pH of the system decreased, the number of negatively charged surface sites decreased and the number of positively charged surface sites increased, which favoured the adsorption of dye anions due to electrostatic attraction. This however did not explain the significant removal of anionic dyes at alkaline pH when the adsorbent surface is negatively charged. The electrostatic, attractive/repulsive theory does not fully explain pH effect. There might be another mode of adsorption, for eg. Chemisorption (ion exchange).

In the case of cationic dyes at high pH, OH^- on the surface of PSP will favour the adsorption of cationic dye molecule. The adsorption of anionic dyes is not as effective as cationic dyes on PSP as a result of their repulsion by the negatively charged adsorption sites on palm shell.

The Freundlich isotherm model showed a better fit than did Langmuir model for adsorption of Rh6G onto PSP. Batch model adsorption studies followed both Langmuir and Freundlich adsorption isotherm models for MB using PSP, acidic anionic dyes, reactive dyes as well as pesticides using APSP as adsorbents which implied that either homogeneous or heterogeneous surface conditions existed under different experimental conditions.

The adsorption capacity of PSP for MB (4.2512 mg /g) was greater than Rh 6G (19.6531mg/g). The adsorption capacity of APSP decreased in the order: Monocrotophos (51.1 mg/g) < Chloropyrifos (52.6 mg/g) < AV7 (243.9mg/g) < DSB (1199.99mg/g) < AOII (2180.05mg/g). The maximum adsorption capacity values of AV7, DSB and AOII were much higher than those of other potential adsorbents, indicating the efficacy of APSP.

The study of effect of temperature indicated that the adsorption of AV7 on APSP and Rh6G and MB on PSP were exothermic which implies a spontaneous reaction while the adsorption of RR141, RB21 on Chitosan, APSP and DSB and AOII on APSP were endothermic. The positive value of ΔH^0 shows that adsorption is favorable at higher temperature and the presence of possible chemisorption phenomenon for anionic dyes (AOII and DSB), reactive dyes (RR-141 and RB-21) . Negative free energy change of adsorption (ΔG^0), negative enthalpy change (ΔH^0) and positive entropy change (ΔS^0) indicate that the adsorption is a spontaneous and exothermic process for cationic dyes (MB, Rh6G), anionic dye AV7 and pesticide (monocrotophos). The negative and low values of ΔG^0 demonstrated the spontaneous and physical nature of adsorption in the case of anionic dyes and Monocrotophos.

FTIR analysis showed that the main functional sites taking part in the sorption of dyes on PSP are N-H & OH Stretching(3422.37 cm^{-1}), Lactones & 5-membered rings (1739.43 cm^{-1}), C=O, N-H bending(1622.64,1510.19, 1460.53 cm^{-1}) and C-O, C-H bending (1379.06, 1250.52 cm^{-1}) and APSP are N-H/-OH (~3419.42 cm^{-1}),- N-H bond of amine / aromatic –C=C- bonds (~1625.29cm^{-1}), C-N stretching (1378.58 cm^{-1})and C-O stretching of the aromatic ring (1200 cm^{-1}).

Various physical forces and the structure of these dyes are responsible for the different extents of adsorption under the reported experimental conditions. Adsorption of organic molecules from dilute aqueous solutions on the adsorbent materials is a complex interplay between electrostatic and non-electrostatic interactions. Both interactions depend on the characteristics of the adsorbent and the adsorbate, and the solution chemistry. Non-electrostatic interactions are essentially due to dispersion and hydrophobic interactions.

Aromatic compounds are physisorbed on adsorbent materials essentially by dispersion interactions between the p-electrons of the aromatic ring and those of the graphene layers. Functional groups of either the adsorbent or the adsorbate profoundly affect these dispersion interactions. In addition, the presence on adsorbent surfaces of functional groups that can give rise to H-bonds with water can effectively reduce the adsorption of the adsorbate molecules.

Adsorption of cationic dyes is due to the electrostatic interaction between PSP and the dye molecule forms a chemical bond is coordinate covalent bond where as in the case of anionic dyes adsorption partly ion-exchange is observed. The adsorption of reactive dyes onto chitosan is electrostatic attraction leads to the higher capacity of chitosan compared to APSP where as in the case of Pesticides weak wandarwaals interaction is taking place.The adsorption of pesticides correlated with K_{ow} values. Thus, two chemical parameters (K_{ow} and K_a) seem to play an important role in the sorption process.

The structure of the dye molecules is an important factor. Increase in reactive and anionic dyes removal efficiency with low molecular weight dyes and less complex structure dyes indicated physisorption as a probable removal mechanism.

PSP and APSP were found to have fast kinetics for the adsorbates under study. The kinetic models tested, suggest the adsorption process is complex and more than one step is involved in the adsorption process. In the process of dye adsorption initially dye molecules have to first encounter the boundary layer effect and then it has to diffuse from boundary layer film onto adsorbent surface and then finally it has to diffuse into the porous structure of the adsorbent. This phenomenon will take a slightly longer time after the initial adsorption. A rapid uptake of pollutants of this study and establishment of equilibrium in a short period signifies the efficacy of that adsorbent for its use in wastewater treatment. In physical adsorption most of the adsorbate species are adsorbed within a short interval of contact time.

Overall it can be concluded that the adsorbents, PSP used for removal of Cationic dyes and APSP used for removal of anionic, reactive dyes and pesticides in this study showed good performance with the advantages of low- cost and large availability. They can be employed as an alternative to commercial activated carbon. However, further research has to be done on the study of competitive adsorption, for instance between NOM, heavy metals, anions and micro-pollutants such as pesticides and dyes to increase its industrial importance. Recovery of the adsorbate from adsorbent has to be studied, which could enable us to use the adsorbents a number of times. The same material may be an effective adsorbent for the removal of various inorganic or organic contaminants for aqueous solution.