CHAPTER 7

ECOLOGICAL AND ECONOMICAL FEASIBILITY

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Phenolic wastes are difficult to treat by conventional biological treatment processes. Phenols are classified as priority pollutants as they are lethal/toxic to aquatic and human life due to their carcinogenic and mutagenic nature. The lethal dose for humans is reported as 5-10 mg/kg body weight. When phenol-containing water is chlorinated, toxic polychlorinated phenols can result thereby contributing bad odor and toxicity to drinking water at very low concentrations (2 μg/l). They may taint the flavor of fishes grown in phenolic water at 5-25 mg/l concentrations. Aquatic life is adversely affected by phenolics even at ppm levels. Phenols have relatively high oxygen demand (theoretically, 2.4 mg O_2/ mg phenol), due to which even less concentration can deplete the oxygen of receiving body. Untreated discharge of such phenolic waste cause a serious problem for the living being on the earth and hence regulatory authority has prescribed the standard norms under the water (Preventation and Control of Pollution) Act 1974 and as per Environment Protection Act 1986, all process Industries shall discharge their wastewater after removing the phenolic compounds into the receiving bodies as per prescribed limit. Hence it is must that the phenolic wastewater must be treated to remove phenols to lowest possible level so that the ecology is not affected.

There are several competing methods of treatment of phenolic wastewaters. The choice of system depends upon economical considerations. The evaluation of the treatment costs is today one of the most important aspect, which needs more attention. The overall costs are the sum of the capital costs, the operating costs and the maintenance costs. For a full-scale system these costs strongly depend on the nature, the concentration of the pollutants, the flow rate of the effluent, and the configuration of the reactor.

Recovery of phenols can be evaluated on the basis of value of recovered product versus cost of recovery. In making this evaluation, a credit should be included for the cost of pollution control systems which would be required if recovery were not practiced. The decision between incineration and biological treatment can also be made on economic basis. Biological treatment can be applied to wastes with strengths as high as several thousand mg/l of phenols. Chemical and advanced oxidation methods can be used for treating small volumes of concentrated wastes and as a polishing step after other treatment processes. In advanced oxidation processes, cost of UV light is to be

considered. Some efforts have been done for the evaluation of the operating costs to develop a procedure for the estimation of the electrical consumptions for UV lamps (Bolton 1994, 1996).

For biological treatment good aeration is required because successful operation of a biological treatment system depends on the health and activity of the microorganism population. Microorganisms require sufficient food, oxygen and stable environmental conditions-pH, temperature, etc. if they are to attain optimum efficiency.

Properly designed neutralization basin is required in order to ensure that feed and environmental conditions for biomass are constant. The flow to the wastewater treatment plant should be evened out, or equalized, on a flow basis, a temperature basis, and a waste concentration basis. It is only when these three are kept at constant levels that the plant will operate at optimum efficiency. An equalization tank is installed ahead of the waste treatment plant. It is designed to have a capacity ranging from a few hours to several days, depending on the operational viability of the plant. It should be of sufficient size to bridge the variable operating period and to provide a safety factor for unexpected peak loads of phenolic waste. This increases capital cost due increase in requirement of land required to accommodate equalization, neutralization and biological treatment process.

Activated sludge process considers properly designed tank, oxygen supply and nutrient supply. It possesses the potential of treating aqueous phenolic wastes at reduced capital and operating cost. However, this process has been found to operate at effluent concentrations nearer to 8-10 ppm rather than 1 ppm. Also, in the event of shock loadings even with the best-designed activated sludge process reactors there is always possibility of rise in phenol concentration well above the allowable discharge level. Hence ecological feasibility of this process reduces.

Wastewater with variable phenolic loads is often treated with adsorbents. Ion exchange resins, activated earth, granular and powdered activated carbon, fly ash, etc. are used as adsorbents. Recently fly ash is finding favor because of its no cost and easy availability. Adsorbents have finite capacity for removing phenols from wastewater and eventually become fully loaded. The phenols may be recovered from the adsorbent either by chemical or thermal regeneration. Regeneration is an expensive process. In order to improve the economic feasibility in the case of activated carbon, biological regeneration using coupled system of biodegradation and adsorption (Bioactive activated carbon) has been tried.

Results of batch adsorption studies of phenols on fly ash from different sources indicate that the capacity of fly ash per stage varies from 0.0002 to 0.026 kg phenol / kg of fly ash; corresponding capacity per stage of activated carbon is 0.005 to 0.088 kg phenol / kg of activated carbon depending upon the initial concentration of phenols in water. Phenols from wastewater can be completely removed by contacting with fly ash in batch contactors in series. This has the advantage of utilizing waste material fly ash but the cost of disposal of used fly ash must be taken into consideration. The used fly ash may be used for road construction in combination with coal tar.

Results of bioactive activated carbon studies indicate the 33- 66% regeneration of carbon. Also, shock loading up to 50% of increase in initial concentration did not affect the biodegradability of bacterial strain *P. aeruginosa.* Biosorption could remove phenols in 55 h compared to biodegradation alone which took 136 h. Moreover, biosorption gives complete removal of phenols with the same quantity of activated carbon(Fig. 7.1). Therefore, usage of biosorption is much more economical than biodegradation alone. Similar advantages were observed in case of catechol and 3-aminophenol. This fact has also been reported by Annadurai (2002).

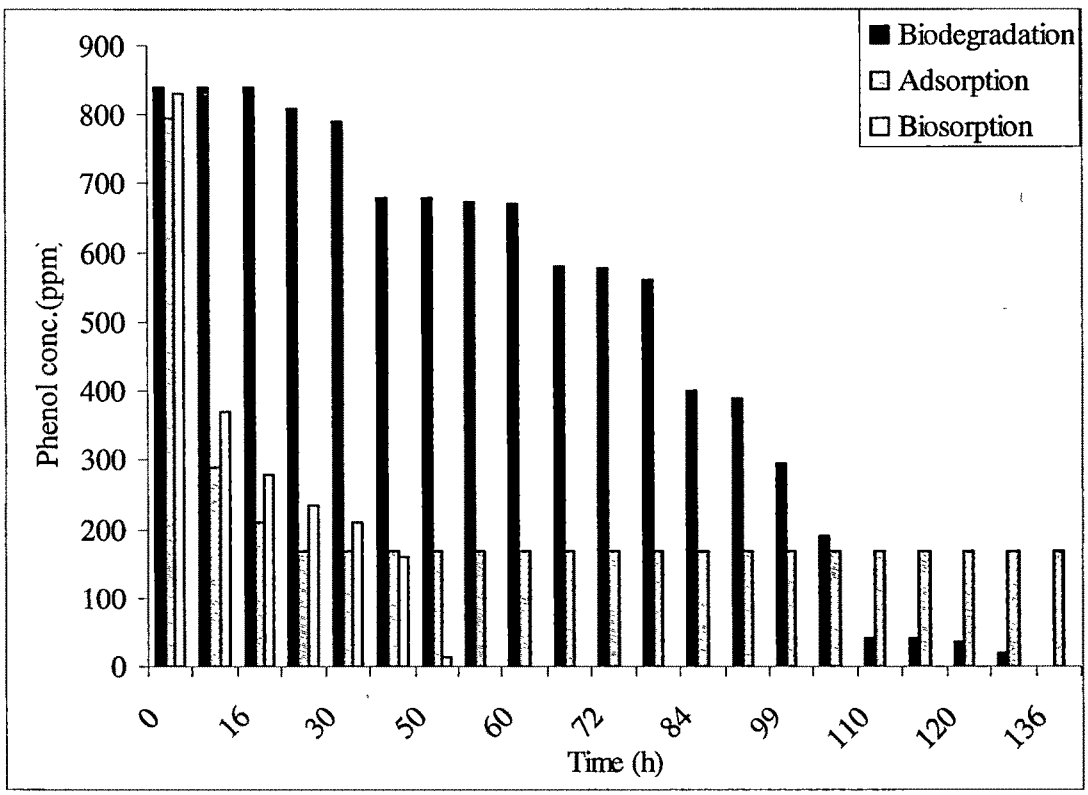

Figure 7.1. Comparison of Biodegradation, Adsorption and Biosorption for phenol removal [Initial conc.= 800 ppm, pH=7.0, Temp.= 30°C]

Economics can be improved through combination of these treatment processes with other methods.

One of the combined processes involves the combination of GAC and ozone to produce biological activated carbon (BAC). This process is a combination of physical, chemical, and biological processes. It is a physical process, because the carrier gas for ozone is either air or oxygen, increases the dissolved oxygen content of the water. The dissolved oxygen is required by a subsequent biological process in which dissolved organic materials and ammonia are aerobically oxidized by bacteria in the carbon adsorption column. It also is a physical process, because the dissolved organics are adsorbed and concentrated by the activated carbon. The bacteria, which adhere to the GAC can more readily, degrade the dissolved organics. Since the dissolved organic materials are more concentrated, biodegradation can take place more readily. Ozone increases the biodegradation properties of a compound because it introduces oxygenated functional groups where metabolism can begin. Large molecule of humic materials is cleaved by ozone into smaller molecules, which are more readily adsorbed by GAC. The net effect of ozone-GAC or BAC process is the production of an efficient means by which low concentrations of dissolved organics can be removed from water. The economics of the process is attractive because granular activated carbon does not require replacement or thermal regeneration. Some installations have operated for 6 years without external reactivation of the carbon (Kirk and Othmer 1980). Ozone dose levels that are required in the BAC process are 1.5-4 mg/l; higher dosages do not substantially improve the efficiency of the process.
The use of ozone in combination with GAC has a synergistic effect, because it allows more dissolved organics to be removed than would be removed by ozone or GAC alone. The main advantage is the lower operating costs compared to using only GAC (Kirk and Othmer 1980).

Biological regeneration of fly ash using coupled system of biodegradation and fly ash can increase the acceptability of fly ash usage in wastewater treatment. Costs for the disposal of used fly ash must be considered while comparing various processes.

Use of solar energy in photocatalytic degradation (PCD) process can improve its economics and this process may become economical(Espulgus 2002, Andreozzi 1999). However it can be used in integration with biological treatment. Phenols are mineralized by PCD into smaller molecules, which are more readily biodegraded. AOP requires much less space than biological treatments, hence where land is very expensive this process is likely to be feasible.

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