International Journal of Research
Available at http://internationaljournalofresearch.org/
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 02 Issue 02
February 2015

Biological Wastewater Treatment for Phenol Removal: A Review

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Abstract:

Various treatment methods used for phenol removal include various chemical and biological treatments. Advanced treatment methods like steam stripping, adsorption, ion exchange solvent extraction, oxidation, phase transfer catalysis and biological treatment processes have been used for phenol removal. Various aerobic and anaerobic treatments are investigated by various researchers. Also combination of different methods coupled with biological process has also been studied. In the present review, various methods used for biological removal of phenol have been summarized. It was found that phenol removal and decomposition by various bacterial pathways was feasible and effective alternative. Biosorption of phenol was simple and effective method for phenol removal. Both suspended and attached growth processes are investigated for phenol removal and can be potentially effective choice for biological phenol removal.

Keywords:

Bacteria, growth, percentage removal, aerobic and anaerobic processes.

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Introduction

Phenol is one of the major pollutants in the wastewater from the industries like resin manufacturing industries, dye synthesis units, pulp and paper mills and pharmaceutical industries, petroleum refineries, coal gasification operations and liquefaction process[1,2]. Phenol can cause various diseases like diarrhea, impaired vision, and excretion of dark urine in human being. It is also toxic to fish and aquatic life. Various removal methods used for phenol from water includes polymerization,electro coagulation, biological methods, extraction, Photodecomposition, Electro-Fenton (EF-Fere) method, Advanced oxidation processes, adsorption and ion exchange and membrane based separation[3,4,5,6,7]. Phenol removal by using various adsorbents is very effective alternative [8, 9,10,11,12]. Various low cost materials like rice husk, groundnut shells, tamarind bean shells, leaf litter were very efficient for phenol removal [13,14,15]. Various biological methods, both aerobic and anaerobic were investigated by various investigators. The current review summarizes research on biological treatment of wastewater for phenol removal.

Research on Biological Methods for Phenol Removal from Wastewater

Basha et.al carried out review on biological phenol removal[16].They described sources of phenol and various microorganisms involved in phenol degradation. They also discussed the kinetics of bactrorial degradation. According to this review, microorganisms can tolerate pH in the range of 4 to 9 within the usual mesophilic operational range from 10 to 30°C. Coal gasification effluent was treatment was treated for phenol removal by Roux and Bohmer[17].They carried biodegradation of phenol in a biofilter. They were able to biodegrade phenol but were not able to reduce other colour imparting components. It was concluded that it was possible to partially degrade phenol and organic matter in the biofilter. Combined biological and enzymatic process was used for phenol removal by Bevilaqua et.al[18].They used biological, combined biological/enzymatic process for phenol removal. In their investigation they were able to remove 99 percent phenol from the effluent. According to them enzymatic treatment was very useful tool for reducing residence time in biological reactors. It also helped to reduce the stress caused due to high pollutant load. Thuy and Visvanathan carried out investigation on removal of inhibitory phenolic compounds by biological activated carbon coupled membrane bioreactor[19]. They used two membrane reactors, namely activated sludge coupled with MBR (AS-MBR) and biological granular activated carbon coupled with MBR (BAC-MBR). According to them phenol removal was mainly due to biodegradation. Semifluidized Bed Bio-Reactor was studied for phenol removal by Meikap and Rot[20]. In their studies they also highlighted the harmful effects due to the presence of phenolic compounds in industrial waste waters. They described the degradations for phenolic compounds. They concluded that the immobilized semifluidized bed bioreactor was a novel and efficient appliance. According to them, in order to make the

process cost effective in the long run, it is desired to have a proper choice of immobilized culture, careful consideration of various design parameters for a semifluidized bed bioreactor. Duan studied microbial degradation of phenol by activated sludge in a batch reactor[21]. In their investigation, they noted that the optimum pH for the treatment was 6 and the temperature doesn't affect the process to a significant extent. Haldane kinetic model was followed by phenol uptake process. Anaerobic biological treatment was used for phenol removal by Collins[22]. They used hybrid expanded granular sludge bed-anaerobic filter (EGSB-AF) bioreactors. They observed that efficient phenol degradation was achieved in a psychro-phillic anaerobic reactor. Operating temperature of 18 ^{o}C was suitable for this operation. Vijayagopal and Sabarathinam studied the kinetics of biological treatment of phenolic wastewater[23]. Three phase draft tube fluidized bed bioreactor was used by them for the treatment. According to them the phenol biodegradation by biofilm was zero order reaction. They achieved almost 100 percent phenol removal in their studies. According to them, the decisive factors in phenol removal were, the bioparticle diameter and the bioparticle hold-up in the three phase draft tube fluidized bed bioreactor. Microbial route was used for phenol treatment by Das et.al.[24]. They used Bacillus cereus in their research. For a 50 ppm phenol effluent they achieved 98 percent phenol in 60 hours. The phenol removal was linear in first 2 hours and then decreased. It was so concluded that the microbial had remarkable potential for application in bioremediation of phenol and waste water treatment. Agarwal and Balomajumdar carried out simultaneous adsorption and biodegradation of phenol[25]. The experiments were carried out for a multicamponent system. They studied parameters like the effect of process parameters like pH, temperature and contact time on the removal efficiency. At 30^{o}C, pH value of 8 yielded best results. Iron impregnated-granular activated carbon (Fe-GAC) exhibited high removal efficiency of 99 percent for adsorbent dose of 10 g/l with 99 percentage phenol removal. Firozjaee et.al. carried out investigation on biological phenol treatment by using an anaerobic continuous stirred tank reactor[26]. They obtained maximum phenol removal in 4 days. Phenol removal of 89 percent was achieved by them. The chemical oxygen demand corresponded to phenol removal. They obtained highest COD removal of 55.6% at three hydraulic retention times. They observed that Increasing the phenol concentration above 600 mg/L resulted in an increase in the specific substrate removal rate. Bhattacharya carried out investigation on ex situ biodegradation of phenol by native bacterial flora isolated from industrial effluent [27]. They isolated total 28 bacterial forms from three industrial effluent samples. Out of these, three showed considerable growth and degradation of phenol. They also studied effect of parameters like auxiliary carbon sources, nitrogen sources, pH and temperature on the growth and aerobic degradation potential of the isolates. Optimum temperature obtained by them was 30 degree Celsius and optimum pH was 7.

Conclusion

Phenol removal can be carried out by various biological methods, both aerobic and anaerobic. Suspanded growth processes includes activated sludge process in which activated sludge used as biosorbent as well as medium for microorganisms. Attached growth process includes tricking filters and biotowers. Different type of biological methods and equipments used by investigators include combined biological and enzymatic process, biofilter, activated carbon coupled membrane bioreactor, semifluidized bed bio-Reactor, hybrid expanded granular sludge bed-anaerobic filter, three phase draft tube fluidized bed bioreactor. It can be concluded that biological methods are effective alternative for phenol removal from wastewater. There is scope for more research in order to economize the biological treatment methodology to make it more economical, acceptable and environment friendly.

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p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 02 Issue 02
February 2015

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