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Recent Investigations for Phenol Removal from Effluent: An Insight into Research and Studies from 2013 to 2017

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ABSTRACT

Various methods for phenol removal include physico-chemical, biological and chemical methods. The author has carried out review on various methods for phenol removal earlier in 2013. According to his review then, adsorption was the prominent research area in the phenol removal, followed by photochemical and chemical methods. The research on batch, column studies with low cost adsorbents has been reported by the author. Column studies were carried out to optimize parameters like flow rate, bed height, initial concentration. This review focuses on the research and studies carried out for phenol removal since 2013. The studies indicated that many new investigations are reported. However it was noted that many investigations are repetitive. There needs to be scale up studies and pilot plant studies for implementation of the research in actual practice.

Key words: Sorption, ion exchange, oxidation, degradation, enzymatic treatment.

INTRODUCTION

Phenol removal is still attracting the investigators due to the wide scope for research in terms of increase in efficiency and economy. It has very harmful effects on man and environment. [1-5] Various methods for phenol removal include physic-chemical, biological and chemical methods. The author has carried out review on various methods for phenol removal earlier in 2013. [6] According to his review then, adsorption was the prominent research area in the phenol removal, followed by photochemical and chemical methods. [7-11] The research on batch, column studies with low cost adsorbents has been reported by the author. Column studies were carried out to optimize parameters like flow rate, bed height, initial concentration. [12,13] Also various models were used for studying breakthrough curves. [14,15]

REVIEW ON VARIOUS METHODS FOR PHENOL REMOVAL

Advanced oxidation process (AOP)

Covinich et. al. reviewed advanced oxidation process (AOP) for phenol removal. [16] Their emphasis was on pulp and paper industry effluent. According to them, large volume and their refractory nature of waste water from industries make them more dangerous. The capability of exploiting the high reactivity of HO• radicals is exploited in advanced oxidation processes. Their study indicated that a total mineralization, transforming recalcitrant compounds into inorganic substances (CO_2 and H_2O_2), or partial mineralization, transforming them into more biodegradable substances. Attributes such as low selectivity and low reactivity makes these radical useful in AOP. Continuous and effective availability of HO• is commonly accelerated by various methods like UV radiation plus hydrogen peroxide (UV/H_2O_2), Fenton's reagent (H_2O_2/Fe^{+2}), photo-Fenton ($UV/H_2O_2/Fe^{+2}$), and ozone in different combinations (O_3/UV; O_3/H_2O_2).

Freitas et. al. carried out an investigation on phenol removal via advanced oxidative processes. [17] They used a tubular reactor Germetec (model GPJ-463/1) for investigation. Through an ozone distribution chamber; they introduced a gas mixture (O_2 and O_3) inside the chemical reactor. They used a combined glass electrode for measurement of the reaction pH. They studied factors affecting the process such as pH, temperature, Fenton's reagent, UV radiation power and O_3 flow. They found out that at hydrogen peroxide = 38.7 g, ozone flow rate = 3 L/h, almost 100 percent phenol removal was possible.

Galbickova and Soldan carried out an investigation on use of advanced oxidation for phenol removal. [18] They used red mud and black nickel mud for increasing the rate. By ozonization without catalyst, they were able to remove 95 percent of the phenol. Chiong et.al. carried out an investigation on phenol removal from wastewater using peroxidases. [19] According to them, highly selective nature of enzymatic reactions, coupled with mild conditions and shorter reaction times are advantages of this method. Their investigation indicated that the method has significant potential and capacity for treating phenol containing aqueous solutions. Schoof et. al. carried out an investigation on Soybean peroxidase (SBP)-catalyzed removal of phenol from a petroleum refinery sour wastewater. [20] They also conducted nitrification and denitrification reactions after enzymatic treatment for various phenol concentrations. This was done in order to find the phenol concentration corresponding to complete inhibition.

Ion Exchange and Sorption

Víctor-Ortega et. al. carried out an investigation on polymeric resins for removal of phenol. [21] For these equilibrium studies, they used Amberlyst A26, a strong-base anion exchange resin, and Amberlite IRA-67, a weak-base anion exchange resin. They studied factors such as phenol concentration and circulation time. Langmuir isotherm indicated best fit for the data. Their studies revealed that Amberlyst A26 had spontaneous phenol uptake, which was not the case with Amberlite IRA-67.

Ratpukdi used activated sludge for treated of phenolic based pharmaceutical contaminated wastewater. [22] He used commercial medium with chemical oxygen demand (COD) of 300 mg/L for growth and acclimation of activated sludge. He carried out experiments to investigated phenol degradation potential of activated sludge in concentration range 0-100 mg/L. He also carried out hourly measurement of COD, phenol and mixed liquored suspended solids (MLSS). His investigation indicated that initial phenol concentrations and COD largely affected wastewater treatment and phenol removal efficiencies.

Un and Gul carried out an investigation on adsorption for phenol removal. [23] They used activated carbon prepared from the dates' stone. They carried out an investigation on parameters like initial pH (3 and 9), temperature (20^{o}C and 50^{o}C), adsorbent dosage (0.1g and 0.2g) and agitation time (1h and 2h).They observed an increase in phenol removal with increasing adsorbent dosage, temperature and agitation time. Phenol removal decreased with the increasing pH. pH value of 3 found to be optimum. For 30 ml sample, 0.2 g phenol was optimum dose with 99 percent removal at 50 C. An investigation was carried out by Saravana Kumar and Kumar on phenol from aqueous solution by adsorption on zeolite. [24] They used sodium zeolite for phenol removal. In their investigation, they identified optimum values of parameters such as pH (3 to 6), contact time, amount of the adsorbent and adsorbent equilibrium. They found that the experimental data fitted very well to the Langmuir model. Dakhil used sawdust as an adsorbent for phenol removal. [25] He studied parameters like initial phenol concentration, adsorbent dose, and pH and contact time. A second order polynomial mathematical model was used to describe the data. The results indicated that pH value of 6.7, 0.82 gm of adsorbent dose and 130 mg/l of initial phenol concentration, and 120 min of contact time were optimum conditions. These conditions were optimum parameters for 100 ml of effluent.

An investigation was carried out by Shirzad-Siboni et.al. On equilibrium and kinetics of phenol removal from Aqueous Solutions by activated red mud. [26] They used scanning electron microscopy and energy dispersive X-ray spectroscopy for studying the morphology and surface components of activated red mud. They found that a pseudo-second-order kinetic model explained the adsorption. Girisha et.al. carried out an investigation on removal of phenol from wastewater using tea waste. [27] They treated waste with sulphuric acid to enhance the properties. They studied effect of parameters like pH, concentration and dosage on the percent removal. They used Freundlich, Langmuir and Temkin isotherm models for equilibrium is otherms studies for phenol adsorption. They found that pseudo-second order model fitted the experimental data reasonably well.

According to Kulkarni, phenolic effluent causes various long term and short term health problems. [28] Various biological and non-biological methods can be used for phenol removal. He reviewed various biological methods for phenol removal. Various suspended and attached growth processes can be used for phenol removal. The percentage removal by using various bio sorbents ranges from 75 to 90 percent for various bio sorbents. Minimization of waste disposal problem is added advantage of this process. He, along with Dr. Kaware also carried out an investigations with groundnut shell as an adsorbent for phenol removal. [29] Removal up to 92-98 percent was obtained during the investigation was obtained by him.

Kulkarni studied fixed bed removal of phenol. [30] His study emphasized that fixed bed operation is most convenient and accepted method for phenol removal by sorption. Kulkarni and Kaware also reported effective removal of phenol by using rice husk adsorbent. [31] For initial concentration of 1,000 mg/l and 100 ml of effluent volume, optimum contact time, pH and adsorbent dose were observed to be 100 minutes 5 and 2.5 grams respectively. Their data was well explained by second order kinetic equation and Freundlichisotherm. An investigation was carried out by Obi and Woke to study use of Colocasia-esculentaaraesia Linn Schott for phenol removal. [32] They studied effect of parameters such as pH, contact studied factors like time and concentration of phenol. They found that the Langmuir adsorption model fitted the data. Kulkarni reviewed phenol removal by biological methods. [33] The experiments carried out by various researchers included use of various adsorbents, bio sorbents, aerobic and anaerobic biological mechanisms. An investigation was carried out by Kumar and Prashanti for use of tamarind nut and commercial activated carbons for phenol removal. [34] They observed that with increase in temperature percentage removal of phenol decreases.

Biological and Enzymatic Pathways

Agarwal et.al. reviewed enzymatic treatment of phenols in wastewater. [35] They studied use of L-tyrosine as a substrate for characterization of tyrosinase activity. They found that maximum at pH value of 7. Their studies also indicated that chitosan was effective in inducing precipitation of toxic compounds. Tyrosinase treated waste had lower toxicity than peroxidase enzymes treated samples. Oxygen as an oxidant make Tyrosinase treatment effective alternative. Khavarpour et.al investigated chitosan-immobilized Pseudomonas putida for Phenol removal from industrial wastewater. [36] They carried out experiments with phenol concentration ranging from 50 to 200 mg/l. To improve phenol degradation, they used Phenol/ glucose mixture used as dual system.

Electrochemical Process

Srinivasulu et. al. carried out investigation on electrochemical method for phenol removal from wastewater. [37] They studied parameters like pH, current density, temperature, initial concentration and cathode speed. They found that with increase in current density, electrolysis temperature and cathode speed, the phenol removal increased considerably. They found that the phenol concentration of 125 mg/L inhibited the process.

Other

Subha et. al. reviewed various removal methods for phenol. [38] According to their studies and their subsequent conclusion, adsorption is effective method. The reason for this lies in its simplicity, economic and easy design. Review on adsorption for phenol removal was reported by Kulkarni and Kaware. [39] This review provided insight on research on adsoption for phenol removal till 2013.

A review by Si et.al. Discussed investigations on phenol in industrial waste water. [40] In their review, they discussed investigations on phenol removal by methods such as advanced oxidation processes, biological fluid bed method, drop phenol bacteria method, light catalytic drop phenol method, peroxidase method, extraction method and biological tower method.

CONCLUSION

The research on batch, column studies with low cost adsorbents has been reported by the author. Column studies were carried out to optimize parameters like flow rate, bed height, initial concentration. The review focuses on the research and studies carried out for phenol removal since 2013.

The studies indicated that many new investigations are reported after 2013. However it was noted that many investigations are repetitive. There needs to be scale up studies and pilot plant studies for implementation of the research in actual practice.

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