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A Review on Packed Bed Removal of Organic Matter from Wastewater

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ABSTRACT

Packed bed reactor finds wide application in wastewater treatments. Packed bed reactors can be employed for aerobic and anaerobic biological treatment of wastewater. They can also be used for physico-chemical treatments such as activated carbon adsorption of various pollutants from wastewater. Packed beds with up flow and down flow mechanisms are widely used for wastewater treatment. Use of fluidized bed offers some advantages such as better contact and better distribution of material. Removal of organic matter from the effluent is major objective behind most of the treatment processes. Packed bed and fluidized bed reactors can be used efficiently for organic matter removal. The present review summarizes the packed and fluidized treatment of the wastewater for removal of organic matter.

Keywords: Adsorbent, organic matter, break through curve, saturation, hydraulic retention time.

I. INTRODUCTION

The presence of organic matter in industrial and domestic effluent affects the aquatic life, flora and fauna. It reduces the dissolved oxygen content of water which is crucial for fishes and aquatic life. The limit for chemical oxygen demand for disposal of wastewater is 250 mg/l in India. Various biological methods such as trickling filters and activated sludge processes are used for COD removal of wastewater[1,2,3,4]. Membrane separation, electro coagulation and ion exchange processes are also promising options for organic matter removal [5, 6,7]. Use of low cost adsorbent for COD removal is studied by various researchers[8,9,10,11]. Batch experiments for COD removal by using low cost adsorbent derived from various waste material have yielded promising results [12,13,14,15]. The desorption of used adsorbent from a fixed beds is also important aspect of adsorption studies [16, 17,18]. The present review summarizes the studies and investigation on packed and fluidized bed treatments used for biological and physic-chemical removal of organic matter from the effluent.

II. PACKED BED REMOVAL OF ORGANIC MATTER FROM EFFLUENT

Araujo Jr. and Zaiat carried out investigation on organic matter removal from wastewater in an up flow fixed-bed anaerobic–aerobic reactor [19]. First they operated the reactor anaerobically by varying hydraulic retention time to determine the best operating condition in terms of organic matter removal. Then in the second step, the combined anaerobic–aerobic reactor was operated to remove additional organic matter and nitrogen through liquid recirculation from the aerobic to the anaerobic (anoxic) zone. A 35 h of hydraulic retention time (21 h in the anaerobic zone and 14 h in the aerobic zone) and a recycling ratio (R) of 3.5 were optimum reactor conditions. They concluded that for treating nitrogen-rich industrial waste-water, the up flow fixed-bed combined anaerobic–aerobic reactor was a good option. Fluidized bed reactor was used for organic matter removal from wastewater by Parthiban [20]. He used mesoporous activated carbon (MAC) of 600 µm particles as support material because of their ability to readily attach methanogenic bacteria. When the reactor was started with acclimatized adapted culture, the start up time of the reactor reduced drastically. The kinetics of substrate utilization followed half order model during initial start up. Methane fermentation followed an order of 0.20. Langmuir-Hinshelwood kinetics was followed for the remaining start up with acclimatized sludge. fluidized and fixed-film processes in a single biofilm reactor for organic matter removal were studied by Dolgen et.al.[21]. They investigated organic matter removal performance of fluidized bed, fixed-bed, and

hybrid reactors. According to them, if fluidization period can be set properly, hybrid conditions can provide equivalent efficiencies to fluidized case. When influent COD concentrations were increased to 1,000 and 2,000 mg/L, the efficiencies of each reactor configurations were negatively affected. They obtained overall removal efficiency of 49% for fixed beds. 60-min fluidized bed plus 300-min fixed-bed operations indicated highest removal of 84 percent.

Bhuyar carried out research on an up flow anaerobic packed bed reactor for treatment of domestic wastewater[22]. They performed experiments with hydraulic retention times of 1, 2 and 3 days based on empty reactor volume. They obtained average COD removal of 75 percent for three days hydraulic retention time(HRT). After one day HRT, there was no increase in COD removal. So 1 day was sufficient retention time for COD removal. In their investigation, Naghizadeh et.al. used continuous adsorption experiments to study efficiency of the carbon nanotubes (CNTs) for removal of natural organic matters (NOMs) from aqueous solution[23]. The break through period was found to be longer at lower initial NOMs concentration. multi wall carbonnanotubes (MWCNT) and single wall carbon nanotubes (SWCNT) exhibited 53.46 and 66.24 mg/g adsorption capacity respectively. They also observed that breakthrough time occurs very late and the volume of treated water increased. Dwaraka and Jaya employed immobilized fixed bed anaerobic digester for domestic waste treatment[24]. They used mixed vegetable waste as a nutrient for the development of micro organisms. The reactor attained steady state after four weeks with an average COD removal of 80% to 90%. With influent COD concentration of 226mg/l, more than 80 percent COD removal was achieved. Semifluidized bed bioreactor was used for the treatment of palm oil mill effluent (POME) by Alade et.al[25]. According to their studies, conventional reactor systems were not efficient. Semifluidized bed method, according to them was highly efficient treatment method.

An anaerobic fluidized bed reactor with natural zeolite as support material was used to treat distillery effluent by Fernandez et.al.[26]. In the first set of experiments, they evaluated the influences of the organic loading rate (OLR), the fluidization level (F_L) and the particle diameter of the natural zeolite (D_P). In the second set, OLR from 3 to 20 g COD/ld with 25% of fluidization and D_P in the above-mentioned ranges for reactors were maintained. In both reactors, COD removal efficiencies of 80 percent were obtained. They concluded that the pH of the effluents obtained and COD removal efficiency were not significantly affected by OLR, F_L and D_P. In second set of their experiments the values of pH throughout the operation time remained within the optimum range for methanogenic bacteria. Rao et.al. used laboratory scale fluidized bed bioreactor for studying the Removal of COD[27]. In their work, they acclimatized the bed material with organic feed for about a week. They observed increase in COD removal with increase in operating time. Also, with an increase in COD values of stock solutions, the reactor got stabilized and maximum percentage removal of COD was achieved within lesser period. Removal of dyes in fixed bed micro column was tried by Qada et.al[28]. The used activated carbon as bed material. With increase in initial dye concentration, the slope of the breakthrough curve increased and became much steeper. Also it was observed that the equilibrium capacity and adsorption rate increased with the decrease in the adsorbent particle size. Nikolaeva et.al. treated dairy wastewater treatment by anaerobic fixed bed reactors[29]. Fixed bed reactor was packed with a hybrid material composed of waste tyre rubber and zeolite.They observed that an increase in the hydraulic retention time(HRT) brought about an improvement in the effluent quality. Maximum 82.1 percent removal was achieved for HRT of 5.5 days. They were able to reduce the volume of the reactor five times as compared to conventional digesters without affecting the organic matter removal efficiency. Packed bed treatment for organic matter in distillery effluent was carried out by Amale et.al.[30].They used wood charcoal as an adsorbent in a fixed bed for removal of organic matter from effluent. They observed that there was decrease in exhaustion time with initial concentration. With increase in bed height, the exhaustion time delayed. Kulkarni presented a review on modelling of packed beds for wastewater treatment[31]. According to the review various models like Thomas model, Yoon Nelson model and Modified Dose model are used for describing breakthrough curves. These models were mostly successful in describing the breakthrough curves. According to him the modelling was very important and helpful tool in the adsorption studies and adsorber design as it saves time and effort.

Activated Carbon prepared from waste Nigerian bamboo was used for adsorption and treatment of organic contaminants by Ademiluyi et.al.[32]. They examined adsorption of organics from the refinery waste on the activated carbon. They obtained COD removal efficiency above 60 percent. Packed bed biological reactor was used for COD removal by Shawaqfah[33]. The organic matter present in primary effluent was an easy source of carbon for the bacteria. They observed that a steady state value was reached after the 55 days. They observed 52 percent COD removal in primary wastewater and 30 percent removal in secondary wastewater. Kinetic Studies were carried out by Dey and Mukherjee for an aerobic packed bed biofilm reactor for treatment of organic wastewater[34]. They developed indigenous mixed culture inoculums after collecting sludge from a return line of an activated sludge plant. With increase in organic loading, the COD removal efficiency depleted from 100% to 54%. According to their studies, phenol indicated inhibition to COD removal. They observed that Monod type rate equations combining a zero and first order rate expression was the best fit for the solute uptake.

III. CONCLUSION

Packed bed is very widely studied contact equipment for wastewater treatment. The studies are reported on effect of the parameters like flow rate, contact time, bed height, initial concentration and pH on the breakthrough curve. With initial concentration and flow rate, the break through time decreases and it increase with bed height.

Various models such as Thomas model, Yoon Nelson model, Bed Depth Service Time Model can be used to explain the breakthrough curves. The fluidized and semi fluidized bed beds also yielded promising results with better contact of particles and better mixing of particles with uniform distribution in the bed. The packed and fluidized beds also have been used successfully for aerobic and anaerobic biological treatment of wastewater. It can be concluded that use of packed bed contactor is promising choice for many biological and physico-chemical wastewater treatment operations.

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