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BIOLOGICAL TREATMENT OF PHENOLIC WASTEWATER IN A THREE-PHASE FLUIDIZED BED

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A three-phase fluidized bed was employed for a process of biological treatment of phenolic wastewater. The three-phase fluidized bed consists of small particulate media with biofilms and gas (air) phase for aeration in upflowing liquid (wastewater). The bed was 5 cm diameter and 320 cm high.

In the experiment where activated carbon was used as media, in the case of no mechanical stirring on the top of the column, the particles with biofilms were entrained in the bed, because overall density and terminal velocity of the particles decreased as the biofilms grew. By stripping of grown biofilms from the media with mechanical stirring, biofilm thickness was well controlled, and stable and continuous operation was achieved enough even under the high load condition (about 4 kg-phenol/m^3-bed vol./day).

The effects of biofilm surface area and volume on the phenolic removel rate were studied. The relation between the phenolic removal rate based on the bed voidage and biofilm volume per unit bed volume was ambiguous, while it was clearly shown that the phenolic removal rate was affected by biofilm surface area per unit bed volume.

The effects of media on phenol removal were studied. The media used in this study were activated carbon BAC, cement ball, Toyoura sand and quartz sand. In the case of quartz sand, biofilm grew quite slowly on a small part of the media, and phenol was hardly removed even after one month. In other media, there was no significant difference in the look of biofilms in steady-state of growth and stripping of biofilms. However, Toyoura sand was in need of a long pre-culture period, about three weeks. Two kinds of activated carbon which were of different diameter were used in this study. The larger activated carbon was in need of a longer pre-culture period than the smaller one. In the experiment where the cement ball was used as media, stable and continuous operation was achieved even without mechanical stirring. There was no significant difference in the effects of media on the phenolic removal rate, and the maximum phenolic removal rate based on the bed volume was a fairly large value (2.43 - 4.80 kg-phenol/m^3-bed vol./day) for all of the media used.

A basic design method of the three-phase fluidized bed system for biological wastewater treatment was proposed. The outline of the calculation for the basic design method of this system (Fig. 1) is as follows:

(1) Terminal velocity of particles with biofilms (V_t) is obtained from apparent density of media (ρ_{mw}), diameter of media (d_m), wet density of biofilms (ρ_b) and biofilm thickness expected in steady-state (ℓ). It is considered that biofilm thickness in steady-state is related to type of substrate, pollutant load (L_v), and superficial liquid and gas velocities (respectively U_ℓ and U_g). In the case of biofilm thickness control with

mechanical stirring, biofilm thickness in steady-state is also related to stirring speed.

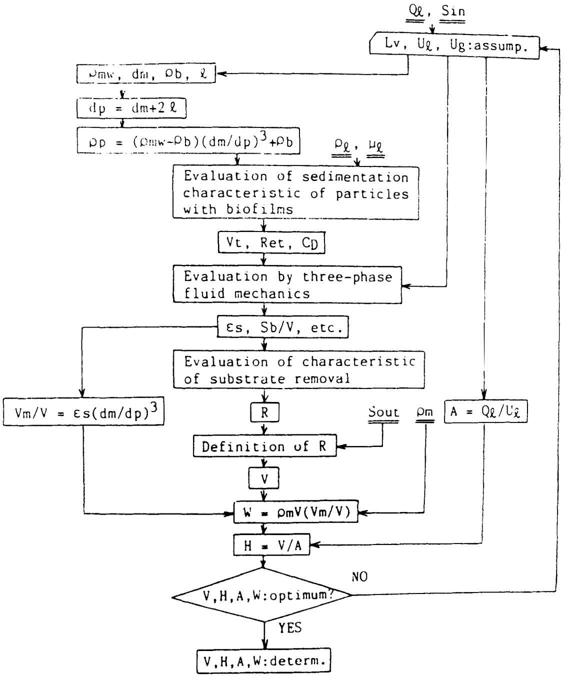

Fig. 1. Calculation flow chart for the basic design method of a three-phase fluidized bed system

(2) Particle hold-up (ε_s) is calculated from terminal velocity of particle, and assumed superficial liquid and gas velocities according to three-phase fluid mechanics.

(3) The substrate removal rate (R) is given from the substrate concentration and biofilm surface area per unit bed volume (S_b/V).

(4) At given inlet and outlet substrate concentrations (respectively S_{in} and S_{out}), bed volume required (V) is calculated by the defined equation of the substrate removal rate.

(5) Bed height (H) and weight of media (W) required are obtained. If the design factors such as bed volume, bed height, bed cross-sectional area (A) and weight of media are optimum under the assumption of superficial liquid and gas velocities, they are finally determined.

Fig. 2-A, B and C show that the values of required bed height, bed volume and weight of media per unit bec cross-sectional area increase greatly with the increase in superficial liquid velocity. So it can be pointed out that the superficial liquid velocity should be designed to be as low as possible under given media and substrate conditions.

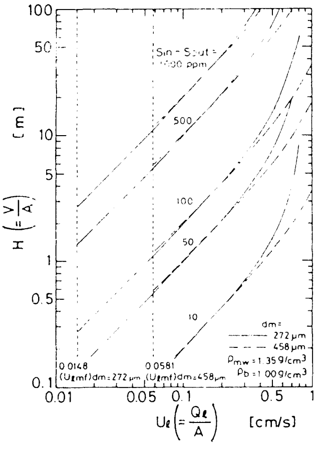

Fig. 2-A. Relation between bed height (H) and superficial liquid velocity (U_{ℓ})($S_{in}-S_{out}$ as parameter)

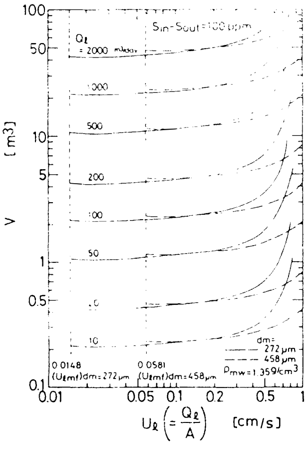

Fig. 2-B. Relation between bed volume (V) and superficial liquid velocity (U_{ℓ})(Q_{ℓ} as parameter)

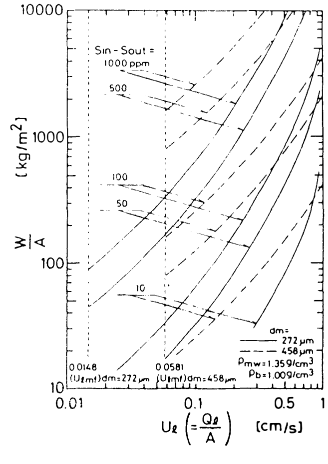

Fig. 2-C. Relation between weight of media per unit bed cross-sectional area (W/A) and U_{ℓ} ($S_{in}-S_{out}$ as parameter)

Fig. 2. Basic design of a three-phase fluidized bed system