동적 상태에서 토양을 이용한 인 제거

이승환, S.Vigneswaran*, 문 희**
한국과학기술연구원 환경연구센터
시드니 공과대학교 토목공학과*
전남대학교 공업화학과**

PHOSPHORUS REMOVAL USING SOIL IN DYNAMIC CONDITION

Seung Hwan Lee, S.Vigneswaran*, Hee Moon**
Environment Research Center, Korea Institute of Science and Technology
*School of Civil Engineering, University of Technology, Sydney
**Department of Chemical Technology, Chonnam National University

INTRODUCTION

Phosphorus (P as orthophosphate) is one of the main nutrients responsible for eutrophication in closed water systems especially in lakes and highly enclosed bays where water is stagnant. Land treatment is an attractive solution if the particular adsorbing media used has significant sorption capacity for P (Ebers and Bischofsberger, 1990). The main advantages of this method over a conventional chemical precipitation process are that it does not produce any excess chemical sludge and does not bring about excessive consumption of chemicals. Furthermore, separation of the phosphate precipitate is not always easily accomplished (Roques et al., 1991). Several researchers have investigated the utilisation of solid materials for P removal (Amended sand with red mud by Ho et al., 1992; Peat and sand amended with iron oxides or steel wool by James et al., 1992; Gravel and industrial waste by Mann and Bavor, 1993). These studies were confined to mainly study the P removal efficiency using those materials. No studies, however, have attempted to study the P transport in the dynamic condition to provide basic information for the design of efficient land treatment facilities. This paper presents the results of laboratory-scale soil column (dynamic) experiments for phosphorus removal. The column experiments were performed to study the sorption isotherm of P and the mobility of P onto soil medium. Mathematical models are presented to predict the P transport under dynamic condition and to verify these results.

THEORETICAL CONSIDERATION

In this study, Equilibrium, Sorption Model (ESM) and Dynamic, Physical, Non-equilibrium, Sorption Model (DPNSM) was used to predict the P transport in saturated column experiments (Lee et al., 1995)

MATERIALS AND METHODS

Adsorbent Analysis

A sandy loam soil from North Sydeny, Australia, was used as the adsorbent for P removal. The characteristics of soil were analysed by standard procedures (Klute, 1986). Percent sand, silt and clay were determined by the hydrometer method. The pH of suspensions in water was measured by a HI8314 Membrane pH Meter. The pycnometer method was used to determine particle density. Permeability was determined by the constant head method. Total element concentrations were determined in an acidified solution by ICPAES (Inductively Coupled Plasma Atomic Emission Spectrometer).

Design of Experiments

The field conditions were simulated in the laboratory by packing the columns with the soil adsorbent. The experimental set-up consisted of perspex columns packed with the adsorbent. A phosphorus solution was supplied to the columns under gravity from overhead containers. The constant head was ensured by providing an overflow tube. The effluent flow was controlled by a flow meter. A sketch of the experimental set-up is shown in Figure 1.

Pre-wetting of the adsorbent was ensured by putting it into a tab water. The concentration of PO_4P in the tap water was less than 0.05mg/l. Care was taken not to allow any air bubbles in the under drainage section and in the media layer. The bulk density was computed from the volume and weight of the media packed in the column. The pH of the P solution in the influent was maintained in the range of 6 to 7. The entire effluent concentration history curve was recorded. The solid phase concentration was estimated in the equilibrium state. To estimate the solid phase concentration, the adsorbent was taken out for air drying at the equilibrium stage of each column.

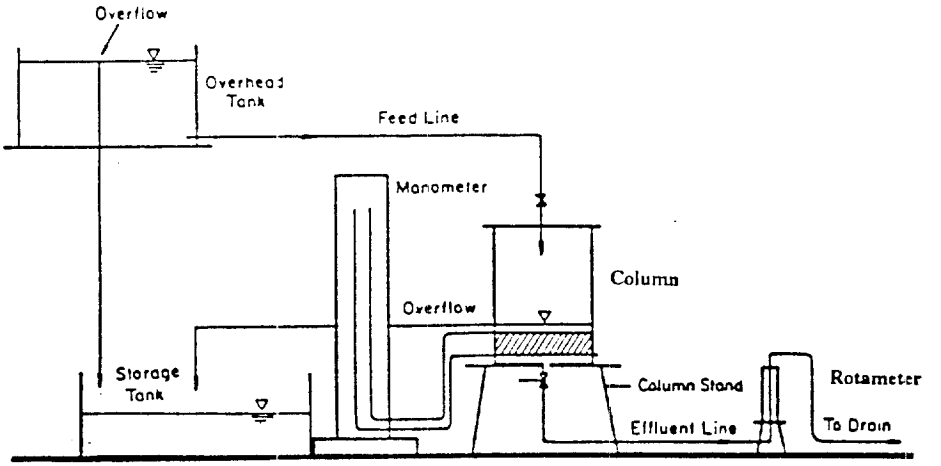

Fig. 1. Column experimental set-up (not to scale)

RESULTS AND DISCUSSION

Sorption Isotherm of P

Experiments on P sorption rates into the adsorbents at different influent concentrations are carried out to estimate the sorption isotherm constants. The equilibrium liquid phase concentration and the corresponding solid phase P concentration determined experimentally are presented in Table 3. The amount of P initially dissolved or retained in the adsorbent was deducted.

TABLE 3 AMOUNT OF P ADSORBED IN THE ADSORBENT

C_o (mg/L)	5	10	20	30	40	50
S_e(mg/g)	0.019	0.036	0.068	0.097	0.126	0.154

Model Validation

The mathematical models presented were fitted to the column experimental breakthrough data for various influent concentrations of P. The DPNSM predictions using dynamic Freundlich isotherms in soil column are shown in Figures 2A to 2B together with the experimental concentration profiles. The dispersion coefficient (D_s) and kinetic mass transfer coefficient (α_s) used in the simulation were obtained by using the fitting program, MCMFIT (Mixing Cell Model FIT).

(A) C_o=10 mg/L (B) C_o=20 mg/L

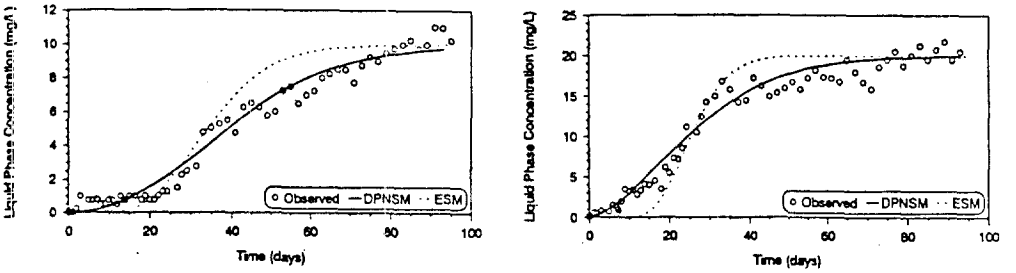

Fig. 2 Phosphorus concentration history curves in soil (C_o=10 and 20 mg/L, w=1.53 cm/day, D_s=0.58 cm^2/day, K=4.55x10^{-3} mg/g(L/mg)^N, N=1.11, α_5=0.18 day^{-1} , H=5 cm, pH=6-7)

CONCLUSIONS

The equilibrium stage was reached faster as the influent P concentration increased. All the columns exhibited characteristic nearly S-shaped or curvilinear breakthrough curves. The simulated results using a dynamic physical non-equilibrium sorption model (DPNSM) and Freundlich isotherm constants K and N (calculated from the column experiments) have satisfactorily fitted the corresponding experimental breakthrough curves. The mobility of P is restricted due to the sorption capacity of soil for P.

REFERENCE

1. Ebers, T. and Bichofsberger, W. (1990). Wastewater treatment by soil absorption systems, *Water Sci. Tech.*, 22, 7/8, 311-312.

2. Ho, G.E, Kuruvilla, M. and Gibbs, R. (1992). Nitrogen and phosphorus removal from sewage effluent in amended sand columns, *Water Resour. Res.*, 26, 3, 295 - 300.

3. James, R.R., Rabenhorst, M.C. and Frigon, G.A. (1992). Phosphorus sorption by peat and sand amended with Iron Oxides or Steel Wool, *Water Environ. Res.*, 64, 699-705.

4. Klute, A. (1986). Physical and mineralogical methods, *Methods of soil analysis*, Am. Soc. of Agronomy, Inc., Soil Sc. Soc. of Am., Inc. Madison, Washington, USA.

5. Lee, S.H., Vigneswaran, S., Bajracharya, K (1995), Phosphorus transport in saturated slag columns: experiments and mathematical models, *Water Science and Technology* (In print)

6. Mann, R.A. and Bavor, H.J. (1993). Phosphorus removal in constructed wetlands using gravel and industrial waste substrata, *Wat. Sci. & Tec.*, 27, 1, 107-113.

7. Roques, H., Jeudy, L.N. and Lebugle, A. (1991). Phosphorus removal from wastewater by half-burned Dolomite, *Wat. Resour. Res.* 25, 8, 959 - 963.