B－28 MEMBRANE SEPARATION BIOREACTOR AND ZEOLITE-IRON COLUMN FOR NITROGEN AND PHOSPHORUS REMOVAL AS AN ON-SITE SMALL SCALE DOMESTIC WASTEWATER TREATMENT

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1.Introduction

The combination of membrane separation bioreactor (MSB) and zeolite-iron (Z-Fe) columns was investigated as on-site small scale domestic wastewater treatment. The membrane separation bioreactor is an activated sludge aeration tank served as equalizing, processing and solid-liquid separation unit, with direct immersion of hollow fiber membrane modules. Not only high degree of organic stabililization was obtained in long sludge age condition but also nitrogen removal was achieved by the introduction of intermittent aeration of 180 minute-cycle. This alternation of anoxic and aerobic condition resulted in simultaneous nitrification and denitrification.

Since the membrane separation bioreactor has been operated without sludge wastage ,phosphorus removal could not be obtained in the system. Phosphorus in the effluent mainly exist in the form of soluble orthophosphate. To upgrade the effluent quality , Z-Fe column composed of layers of zeolite and iron material was used to remove remaining ammonia and phosphorus before final discharge. The iron material used was a waste from industrial manufacturing process. In addition, the zeolite layer used as a support at the bottom of the column could also entrap the iron particles leaching out from the system.

The investigation of the performance of Z-Fe column in treating ammonia residuals and phosphorus from membrane effluent was initially done,and then the experiment with synthetic wastewater was conducted to study the effects of iron bed height and oxygen supply to the performance of ammonia and phosphorus removal.

2.Methods

Experimental Set-up

The schematic flow diagram of the combined system consisting of two unit processes is shown in Fig. 1. Membrane effluent from the storage tank was pumped to a Z-Fe column with different patterns of iron material and zeolite layer- arrangement.

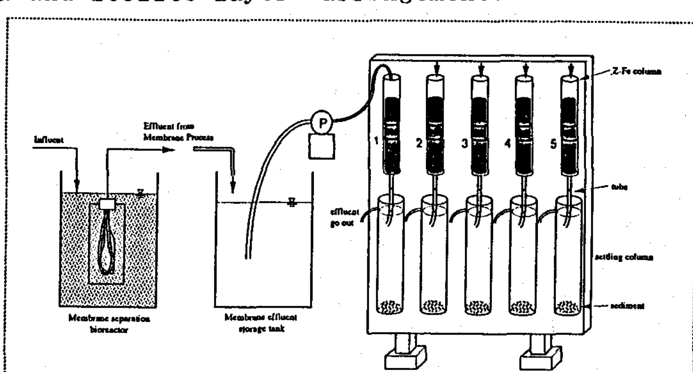

Fig.1 The combination system of MSB and Z-Fe column process

Membrane separation bioreactor unit: The bioreactor of 62 volume was used. Two hollow fiber microporous membranes of 0.03 micron pore size and 0.3 m^3 surface area each were put in the bioreactor. Permeate was extracted by a roller pump under intermittent operation of 10 minutes cycle. Level sensor was used to control feeding equipment and maintain constant volume of mixed liquor. Aeration was also supplied to the system in 180 minutes cycle (90 minutes for non-aerating period followed by 90 for aerating period). pH of mixed liquor was in the range of 6.5-7.5 and operating temperature was about 5°C.

The zeolite-iron column unit: All columns had uniform diameter of 8 cm ,fixing the height of zeolite bed to 17 cm and varying the height of iron bed . A settling chamber was added to the Z-Fe column unit to catch iron particles leached out from the column. Zeolite was a natural clinoptilolite in the size of 7-15 mm with cation exchange capacity of about 160 mg/100 g. Iron material was pretreated before used by 0.01 N-HCl solution to eliminate oil on the surface layer of iron material.

3.Results and discussion

The performance of the combination of MSB and Z-Fe column

First,the performance of the combination system between MSB and a Z-FE column in treating phosphorus and ammonia residuals was investigated.The column with iron bed height of 60 cm was operated at flowrate of 10 l/d.

From Fig.2, it was found that nitrogen removal of 70 % could be achieved in MSB at the influent nitrogen concentration of about 30 mg/l even at low temperature of 5°C. When the influent nitrogen concentration was increased to about 75 mg/l, the nitrogen concentration in the effluent gradually increased to 30 mg/l.

Fig.3 and Fig.4 show the performance of Z-Fe column for the removal of phosphorus and ammonia residuals in the effluent from MSB process. The column still could not remove phosphorus concentration of membrane effluent to less than 0.5 mgP/l which is the target effluent quality in this study. The reason might come from insufficient iron bed height and/or insufficient oxygen supply to the column which prevented oxidation of iron surface layer to fix phosphate. However, zeolite could remove ammonia residuals well due to its high selectivity of ammonia exchange capacity.

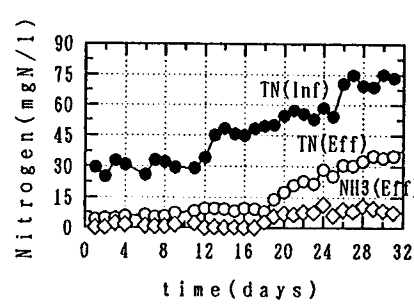

Fig.2 The performance of MSB for the removal of nitrogen

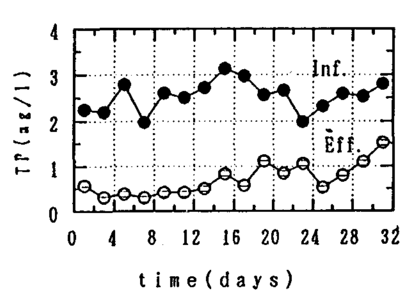

Fig.3 The Z-Fe column for the removal of phosphorus

To investigate the reason why the phosphorus removal by the column could not be achieved well ,two next following experiments were done.

Effect of iron bed height to the performance of phosphorus removal.

In order to study the effects of iron bed height to the removal of phosphorus and ammonia residuals, Four columns were operated , fixing the zeolite height of 17 cm , and varying the iron bed height to 15,30,45 and 80 cm . The synthetic wastewater containing only $(NH_4)_2SO_4$ and $Na_2(HPO_4)$ was used instead of membrane effluent at flowrate of 10 l/d.

From Figs. 5 and 6, the data of one month-operation show that the phosphorus removal rate increased with increasing iron bed height. However, the phosphorus removal per unit iron material diminished with increasing iron bed height.This might be due to the depletion of oxic condition inside long column, which can bring about not only the release of phosphorus in the system but also less phosphorus removal capacity of the iron material surface in the lower part of the column.

Improvement of the performance of phosphorus removal by aeration.

To obtain oxic condition, the aeration was provided to the column with 80 cm of iron bed height after 35 days of operation. Fig.7 shows that phosphorus removal efficiency was significantly improved after 35 days as 90% TP-removal could be achieved. It was resulted from the regenerating of oxidation form of iron surface layer that could fix more phosphorus. However, the iron particles released a lot and caused clogging gradually. The effluent quality became worse again after 20 days of aeration. It seems that aeration can be a way to improve phosphorus removal capacity if the clogging problem is eliminated.

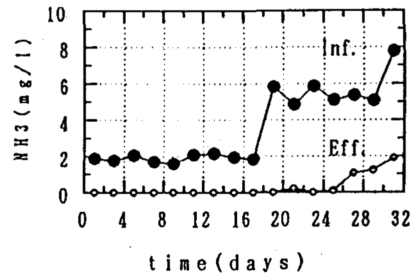

Fig.4 The Z-Fe column for the removal of ammonia residuals

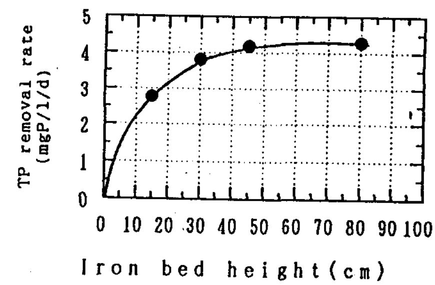

Fig.5 The rate of phosphorus removal for the variation of iron bed height

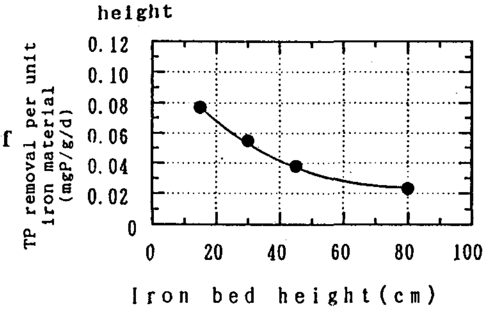

Fig.6 The relationships between iron bed height and the phosphorus removal per unit iron material

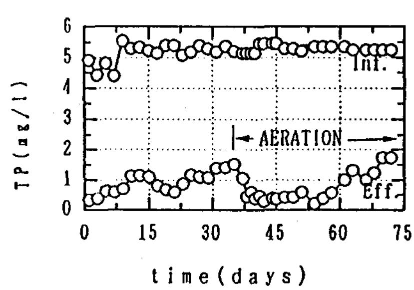

Fig.7 The effects of aeration to phosphorus removal