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Treatment of Organic Waste with Microorganisms of Mixed Population

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This study represents that a removal efficiency of organic matters in wastewater is activated by a sludge process using new mixed microbial population. In case of mixed microorganisms, removal rates of suspended solid (SS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were over 90 percent under experimental condition, and removal efficiency of organic matters, sludge density index (SDI) and capillary suction time (CST) in mixed population were higher than that in not-mixed microorganism, while total kjeldahl nitrogen (TKN) and total phosphorus (T-P) which indicate a degree of eutrophication were removed easily in both case. From these results, we may propose that an application of the mixed microbial population is useful to treat domestic wastewater including a great deal of organic matters.

Key Words : Organic matters, mixed population microorganisms, eutrophication, complete mixing aeration domestic wastewater

INTRODUCTION

A biological wastewater treatment is primarily used to remove dissolved and colloidal organic matters in wastewater. Biological treatment is a natural process by microorganisms. Organic matters in wastewater are decayed as a result of a presence of microorganisms. High loading of organic matters in wastewater upset biocenosis, and this may cause undesirable effects. Biological treatment of wastewater is focused on accelerating natural decay processes and neutralizing the waste.

Recently, there are many kinds of biological treatment processes, which developed in order to improve a removal rate of organic matters in wastewater. However, because they are mostly a high price technique, we must make researches into a new application of microorganisms, related with conventional wastewater treatment processes.

A mixed microbial population used in this study for wastewater treatment consisted of photosynthetic bacteria, lactic acid bacteria, yeasts and other local beneficial microorganisms. Photosynthetic bacteria are autotrophic and use light and heat as energy source. They produce several effective substrates, for example, amino acids, nucleic acids and sugars etc. *Lactobacilli* produces organic acids from sugars and degrades proteins to amino acids under an anaerobic state. Its organic acid products have strong bacteriostatic effects and repression effects against harmful microorganisms. *Saccharomyces* synthesizes available substances reacting with organic matters. *Actinomycetes* produces antibiotic-material. This antibiotic material makes environment favorable for a growth of other microorganisms. *Aspergilli* prevents noxious insects from growing by producing many kinds of alcohols and organic acids. And they can effectively remove malodor(Seol, 1997).

This study was preformed to evaluate the removal efficiency of organic matters under cultivation of mixed microbial population in a sludge process aerated completely. This process provides us potential savings in capital and in operating cost, compared with multi-sludge systems.

MATRIALS and METHODS

Materials

Reactors of two types used in these experiments are composed of a mixing tank, an aeration basin and a clarifier. The aeration basin is equipped with a diffuser and a laboratory mixer at the bottom so that an aerobic condition and a good oxygen transfer can be established by stirring or sparging. A schematic diagram of the sludge process is shown in Fig. 1. The aeration basin is 300 mm × 200 mm × 170 mm acrylic rectangular-typed, and clarifier tank is 200 mm ϕ × 240 mm acrylic round-shaped.

Wastewater used in these experiments were collected from a

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domestic wastewater plant at Chunchon, and its constituents of are shown in table 1. A sample was collected every third day. In order to keep same quality of samples, they were immediately stored in a cooling room at 4℃.

The reactor was constantly stirred and diffused by triangular-type diffuser stones to maintain a homogeneity of suspension. dissolved oxygen (DO) was regulated by control of an air-flow meter. Effluent was discharged by gravity.

A culture of the mixed microbial population was added in the mixing tank and diluted (1/100) by distilled water. It was dosed drop by drop at every second day.

Table 1. Characteristics of the influent samples

Constituent	Conc. Range (mg/L)	Average Con. (mg/L)
pH	6.2 ~ 6.8	6.5
Temperature (℃)	19.4 ~ 26.8	24.0
SS	125 ~ 300	204.5
VSS	100 ~ 160	138.2
COD	134.8 ~ 287	204.7
SCOD	25.8 ~ 70.0	48.7
BOD5	120 ~ 200	152.1
T-P	4.1 ~ 6.1	5.1
T-N	21.0 ~ 32.4	29.3
NH_4 N	8.4 ~ 15.5	12.5
NO_3 N	0.07 ~ 0.19	0.13
Alkalinity	109.0 ~ 192.9	142.3

* Alkalinity : mg/L as $CaCO_3$

* Average concentration : average value of 20 samples

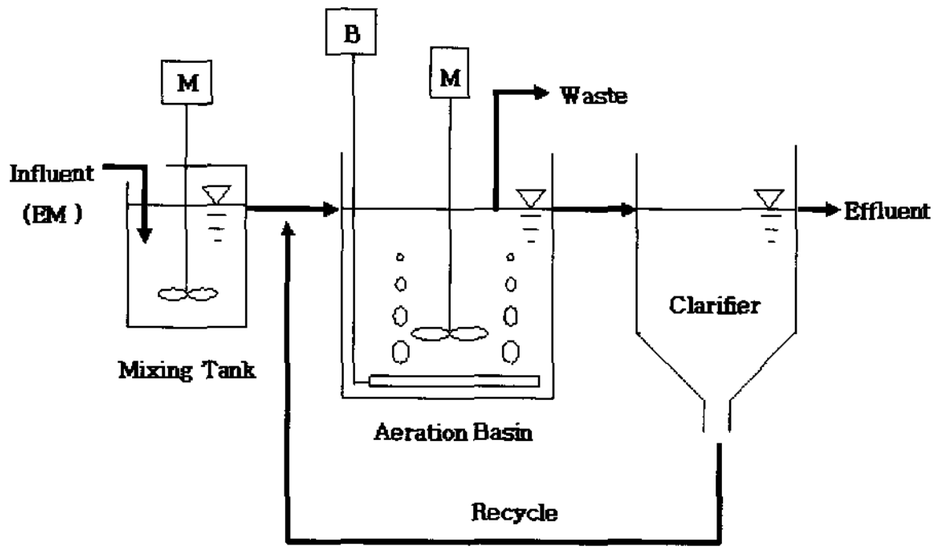

Figure 1. Schematic diagram of sludge process.

Experimental conditions

An activated sludge collected from a municipal wastewater plant of Chunchon, Korea was used as seed and cultured at a BOD loading rate of 0.3 kg BOD kg MLSS 1 day-1. A start-up operation was carried out the acclimatized sludge coming from the municipal wastewater treatment plant. The system without the mixed microbial population addition was operated at the designed SRT of 8, 10 and 12 day. Mixed liquor suspended solids was maintained at about 2,000 mg/L. DO concentration ranged from 4.0 to 5.0 mg/L and return sludge ratio was kept at 0.5 throughout the experiment. The reactor which received the mixed microbial population, however, maintained the DO concentration from 0.5 to 1.0 mg/L, and excess sludge was not wasted. 40 L of wastewater was fed to each set of reactor every day. Predetermined amount of mixed microbial population equivalent to 10% of the influent volume was added into a mixing tank of activated sludge process for the evaluation of efficiency of mixed microbial population in the wastewater treatment. Prior to the addition, mixed microbial population was diluted to 1/100 with distilled water.

Analytical methods

Sampling for analysis of effluents was performed every 48 hours. Samples for an analysis of soluble components were immediately filtered using 0.45 ㎛ filter paper and cooled in order to prevent further reaction or analyzed instantly.

A dissolved oxygen concentration was measured by DO meter (YSI Model 55, YSI Inc., Ohio, USA), and the suspended solids (SS) was analyzed by a gravimetric method. COD was analyzed by a closed reflex titrimetric method according to standard methods (APHA et al., 1995) and BOD was measured by the winkler method based on azide modification(Moran, 1980). The TKN and T-P were analyzed by the micro-kjeldahl method and the persulfate digestion & ascorbic acid method(Gross et al., 1998). The alkalinity was analyzed by a titrimetric method using $CaCO_3$ (Tarre, 1994). Determination of NH_4-N and NO_3-N concentration was performed by the phenate method and the brucin method, respectively(Schmid, 1968).

A capillary suction time test determines a rate of water release from sludge(W. Chen G et al., 1996). It provides us with a quantitative information, reported how easy its own water is released from sludge. The CST test has been used as a relative indicator to characterize a performance of sludge's dewatering processes.

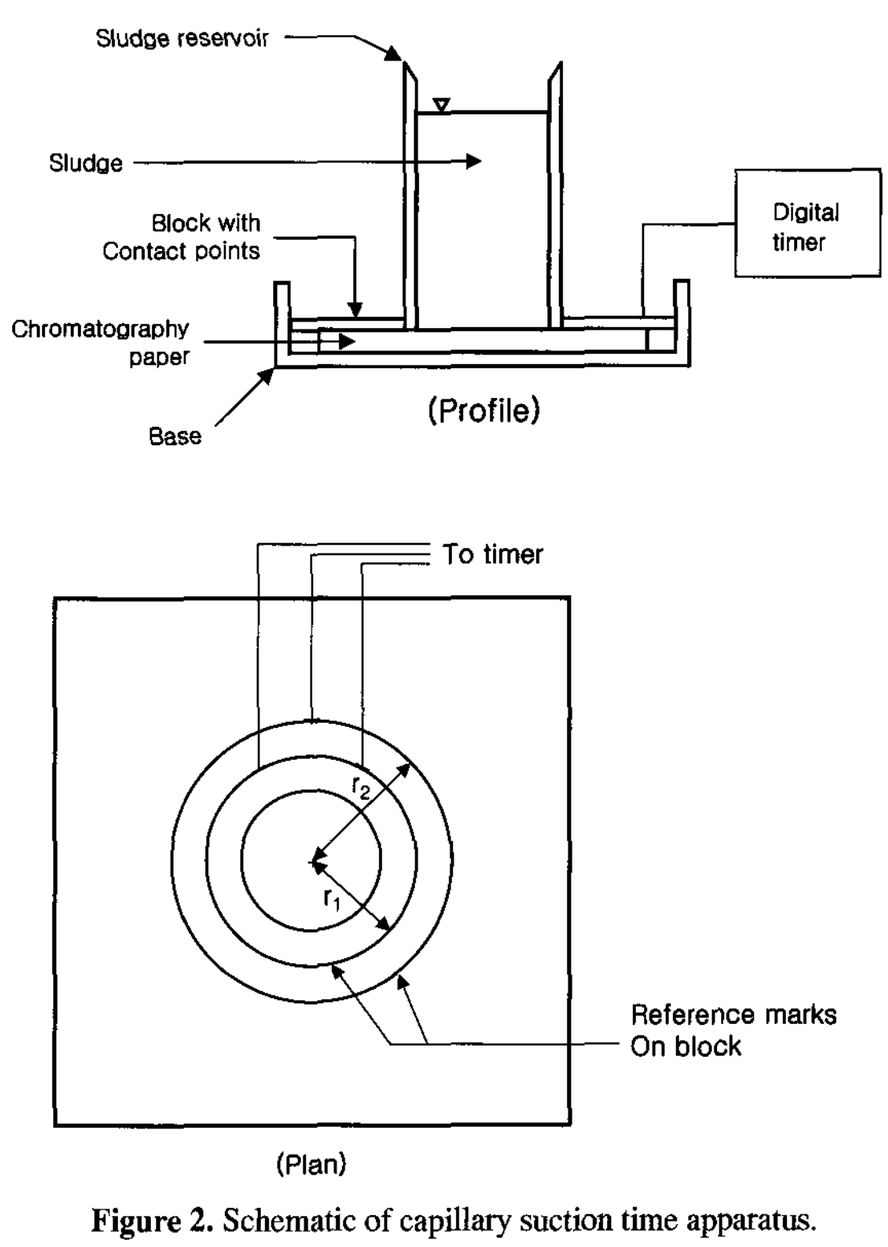

Figure 2. Schematic of capillary suction time apparatus.

RESULTS AND DISCUSSIONS

The sludge process using mixed microbial population was designed for biological wastewater treatment system in order to maximize a removal efficiency of organic matters.

Suspended solids are separated from the solution. Some suspended solids are classified as settleable solids. Experimental results about the removal efficiency of suspended solids in terms with effluent vs time was shown in Fig. 3. From this experiment, we know that the mixed microorganisms has a good effect on a flocculation of organic matters in wastewater. In addition this result, a size of solids formed by mixed microorganisms is bigger than that formed in only activated sludge(This result was not shown in this paper).

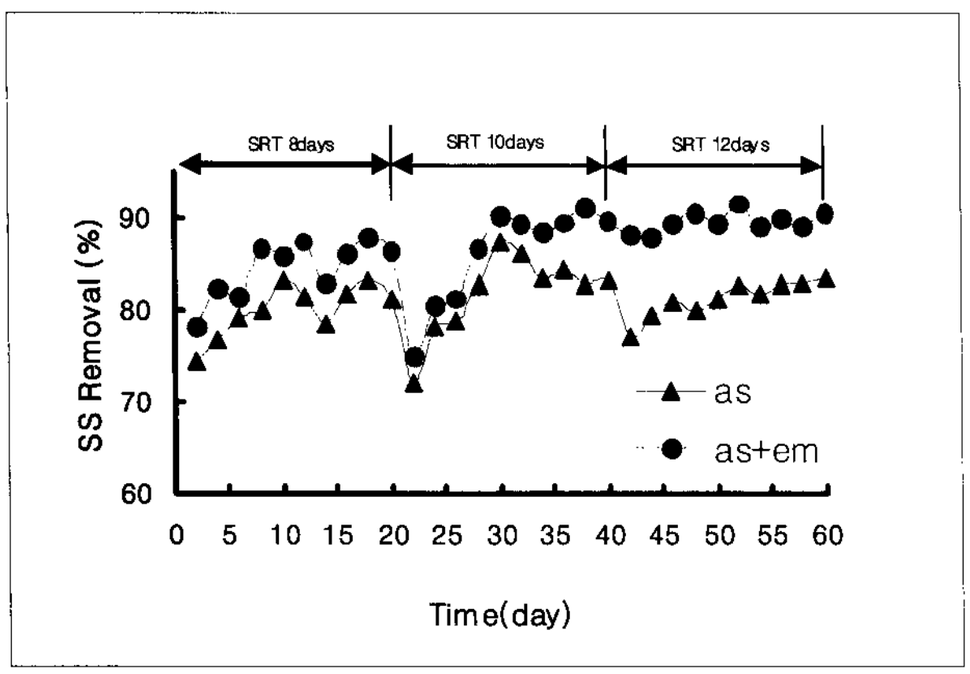

Figure 3. Removal efficiency of suspended solids.

Biodegradable degree in wastewater can be easily calculated by measuring a difference of COD or BOD between influent and effluent. These results were illustrated in Fig. 4 and Fig. 5. In the reactor with mixed microorganisms, like SS removal results, stable and gradual increment was maintained at every cycle, while the reactor containing no mixed microbial populations showed some unstable and low values. From these results, we may assume that the mixed microorganisms are available to remove organic matters in wastewater.

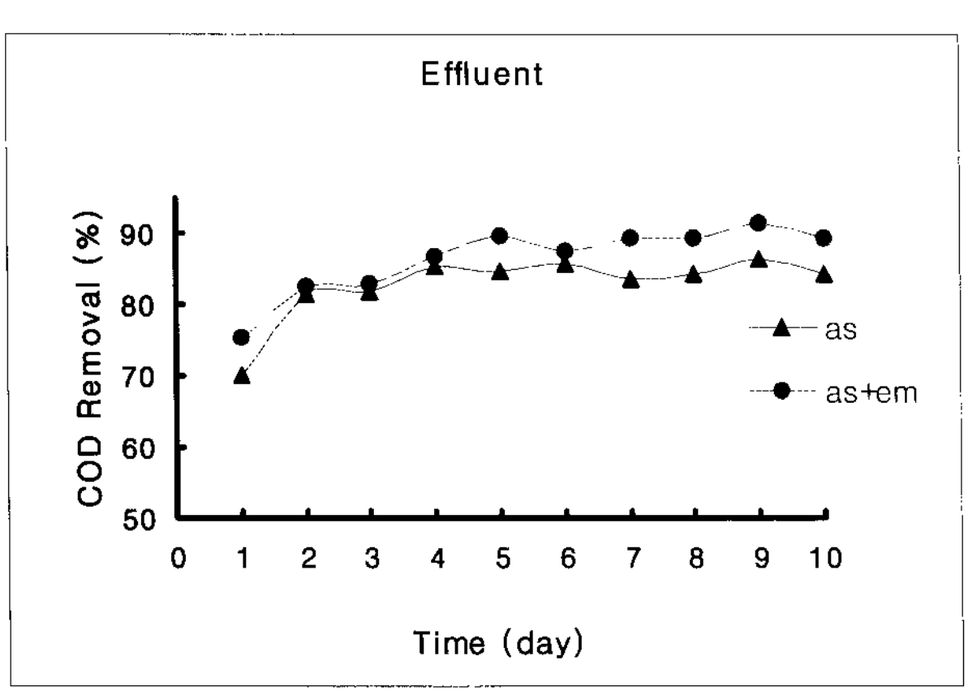

Figure 4. COD removal on operation time.

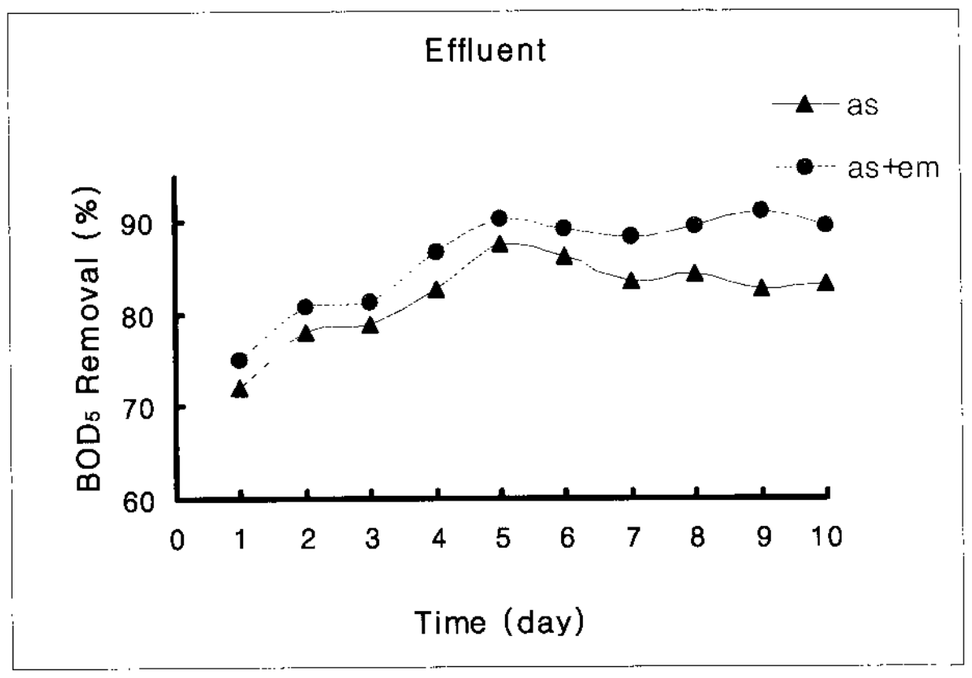

Figure 5. BOD5 removal on operation time.

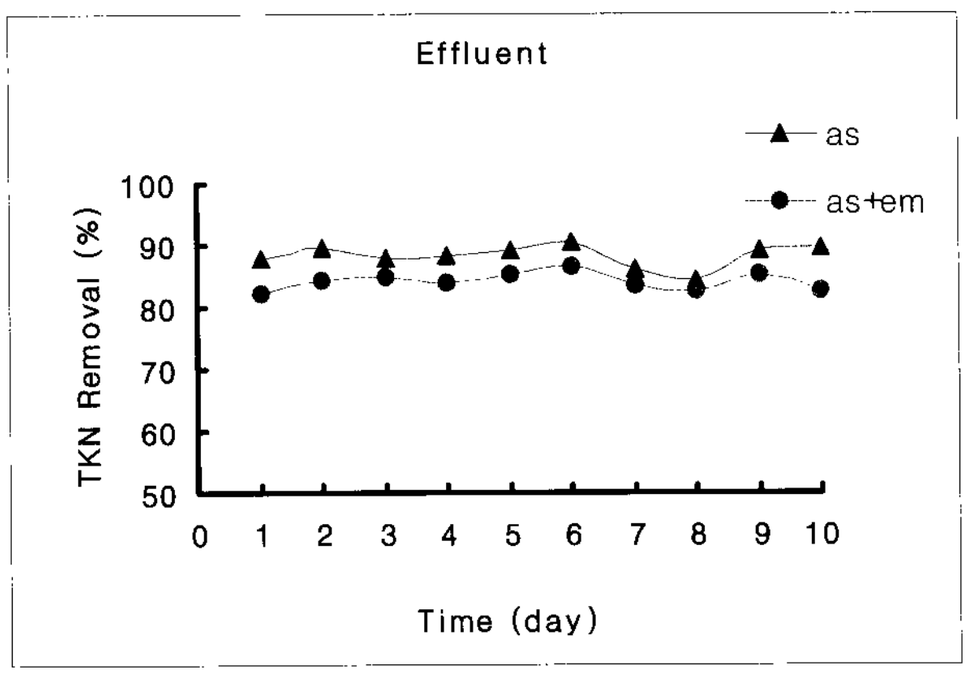

Figure 6. TKN removal on operation time.

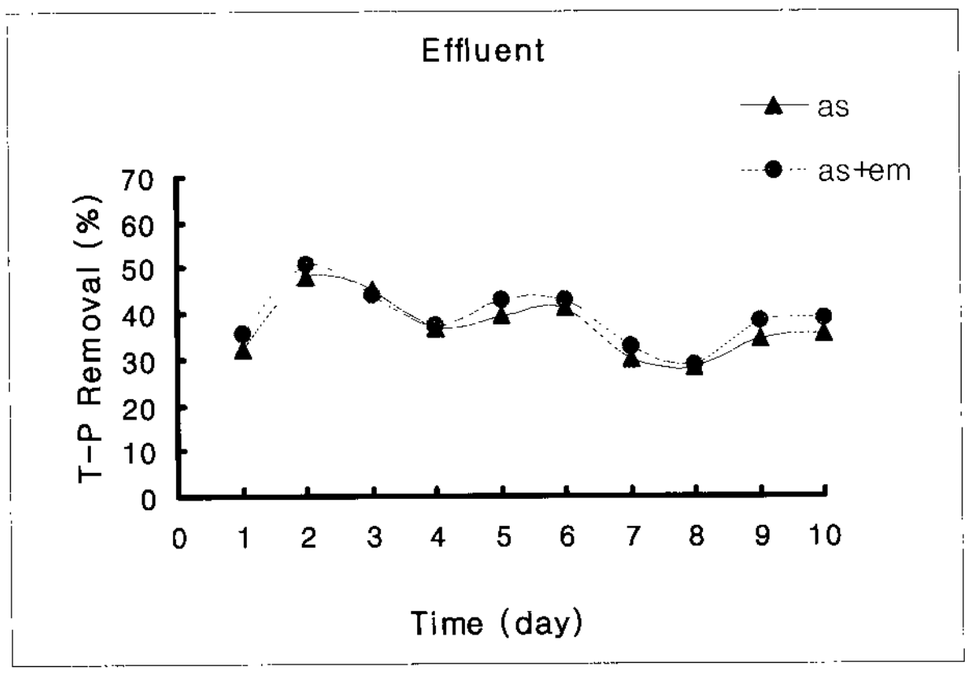

Figure 7. T-P removal on operation time.

A presence of nitrogen in a wastewater can be undesirable for several reasons, for example, free ammonia is toxic to fish and many other aquatic organisms, ammonium ion or ammonia is an oxygen-consuming compound which cause a depletion of oxygen dissolved in receiving water and any nitrogen can cause an eutrophication because of availability as a nutrient to aquatic plants. Wastewater of predominantly domestic origin contains nitrogen in organic or ammonium form. In fresh sewage about 60 percent of nitrogen is in an organic form and 40 percent in an ammonium form. Thus, removal of TKN is important factor on

wastewater treatment. The low removal of TKN was observed in reactor with mixed microbial population. This result may be due to a difference of air's quantity supplied.

Phosphate is recognized as one of the major nutrients contributing to an eutrophication of aquatic environments. Removal of phosphate from wastewater has had much attention in recent years. Our experimental data about removal rate of T-P was presented in Fig. 7. Slightly high efficiency was shown at process with mixed microbial population.

CST test consists of placing a sludge sample in a small cylinder on a sheet of a chromatography paper. The paper extracts liquid from the sludge by a capillary action. The time which is required for the extracted liquid to travel specific distance is recorded automatically by monitoring a change of conductivity occurring between contact point and chromatography paper. An elapsed time indicates a water drainage rate. Results about CST were summarized in Table 2 and showed that sludge of mixed microbial population has higher capacity of dewatering rate than sludge of other case. Blank test was performed with distilled water.

Table 2. Capillary suction time on variation of experimental condition

Item	blank	as + em	as
Conc. (mg/L)	0	7,260	7,250
CST (min)	1.94	4.46	5.57

A settled sludge volume of a biological suspension is useful for monitoring of biological processes. Especially, sludge volume index (SVI) is used to monitor settling characteristic of sludge and other biological suspensions. Sludge density index (SDI) is used for a determination of returned-sludge's flow rate and sludge's settling rate. They are also important indicator for a sludge control. SDI value with over 0.7 means a good settling characteristic. In Fig. 8, SDI value in mixed microorganisms was higher than that in not-mixed. Thus, we estimate that the system using mixed microorganisms bring an improvement of sludge treatment efficiency.

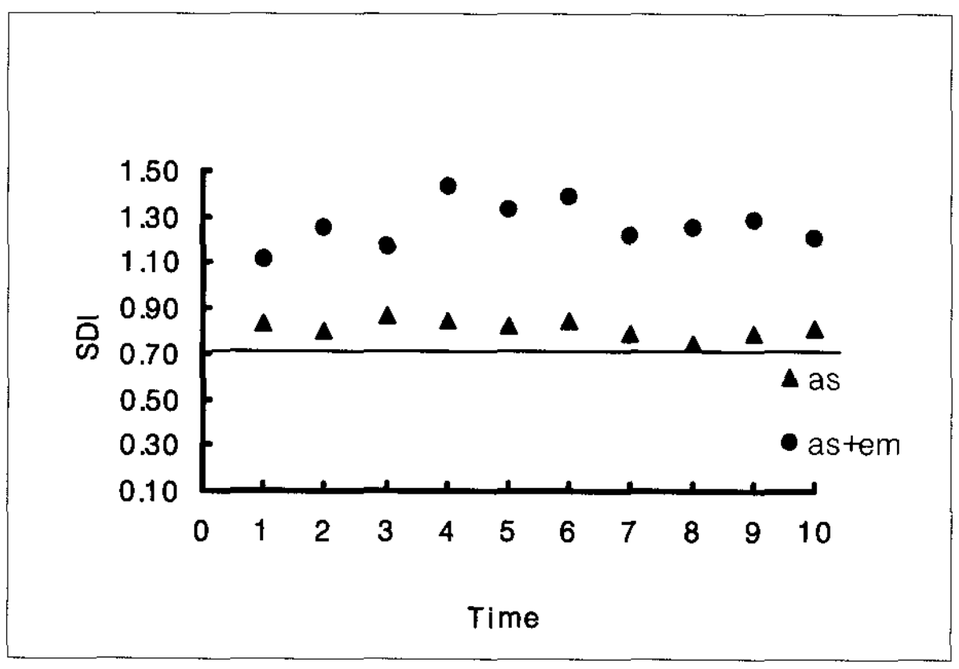

Figure 8. Sludge density index value on time.

Removal rate value of organic matters in wastewater was compared in Fig. 9. High removal rate was found in case of the mixed microorganisms.

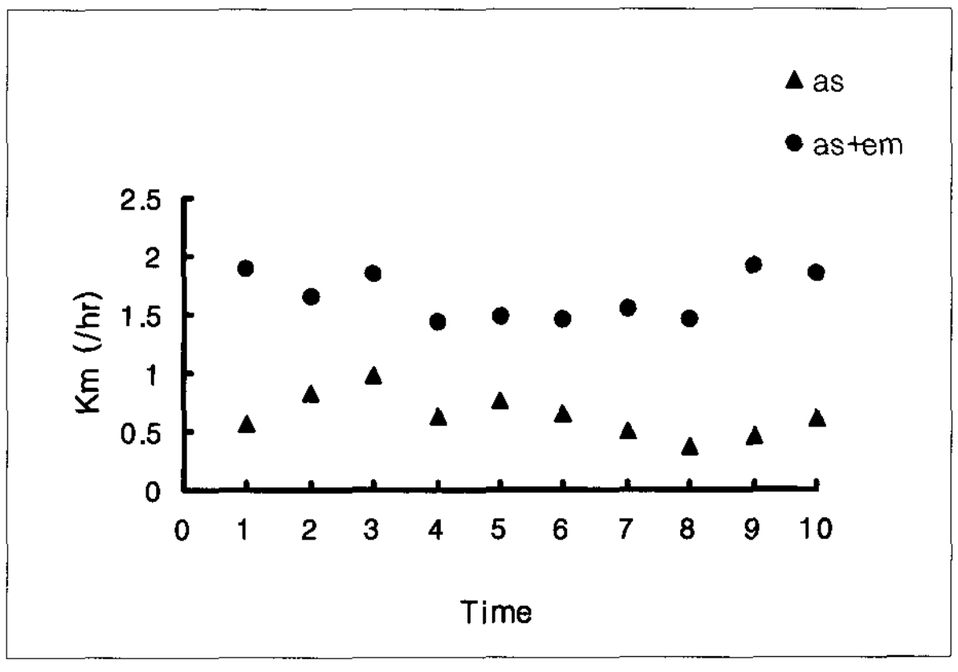

Figure 9. Removal rate of organic matters on time.

CONCLUSIONS

This experiment was carried out in order to investigate the effect of mixed microbial population on the treatment of domestic wastewater that contained organic matters.

The results obtained are as follows:

1. The SS, COD and BOD were removed over 90 percent, in the cases with mixed microorganisms, high removal efficiency appeared

2. The capillary suction time for assessment of sludge dewatering rate represents that the sludge with mixed microorganisms has good water drainage characteristics.

3. From the sludge density index data, the bio-particle formed by mixed microorganisms was settled speedily.

4. The mixed microorganisms have high ability for removal of organic matters in wastewater.

From this research, it is concluded that the mixed microbial population are available for treatment of domestic wastewater containing organic matters

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