International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:4, No:12, 2010

Biological and Chemical Filter Treatment for Wastewater Reuse

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Abstract**—**This study developed a high efficient and combined biological and chemical filter treatment process. This process used PAC (Powder Activated Carbon), Alum and attached growth treatment process. The system removals of total nitrogen and total phosphorus ratio of two were as high as 70% and 73%, moreover, the effluent water was suitable to urban and agricultural water. Also the advantages of this process are not only occupies small place but is simple, economic and easy operating. Besides, our developed process can keep stable process efficiency even in relative low load level. Therefore, this study judges that use of the high efficient and combined biological and chemical filter treatment process, it is expected that the effluent water in this system can be reused as urban and agricultural water.

Keywords**—**biological and chemical filter treatment, wastewater reuse, PAC, Alum

I. INTRODUCTION

THIS study developed a high efficient and combined biological and chemical filter treatment process. Some areas in Korea partially suffers from insufficiency of living water resulting from the intensive urbanization. Besides, due to our climate's nature, most of rainfall concentrates in the period ranging from June to September, so serious drought crisis may break out in May, the season of raising crops. Therefore, it is required to develop a system to recycle the sewage as substantial water for securing urban living water and agricultural water [1]-[2]. In case of purifying sewage water, it is necessary to purify sewage water meet water quality criteria concerning non-degradable organic compounds, nutrient salts and chromaticity for reuse of sewage water in order to reuse sewage water.

So, in this paper, a specific system was developed by using chemical treatment and attached growth process, and agricultural water, which has to meet the most strict water quality criteria for reuse, was examined.

PAC and Alum were used for chemical treatment. PAC and Alum were used for removal of non-degradable organic compounds and phosphorus respectively [3]. The attached growth process was composed of anaerobic and aerobic processes, and was connected to denitrification and nitrification, and phosphorus remainder adsorption processes [4]-[5]. In this paper, the optimal injection volume of each chemical was estimated through basic experiment, and the removal efficiency was examined and evaluated in case of normal operation of system, and interaction between chemicals and effect of chemical treatment on biological treatment were also examined to suggest optimal operation factors.

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II. EXPERIMENTAL

The above-mentioned system is the combination of chemical treatment and biological treatment. 100mg/L of PAC and 30mg Al/L of Alum were injected through jar-test, and interrelationship between chemicals were examined, and then, effluent water was analyzed.

In case of concurrent injection of PAC and Alum, chromaticity, turbidity, non-degradable organic compounds and removal efficiency of phosphorus were checked through jar-test, and nitrification efficiency due to reduction of alkalinity of Alum, and reduction characteristics of denitrification efficiency due to Methanol adsorption of PAC were examined.

Biological treatment is the attached growth process, and may be classified into two processes: anaerobic and aerobic filter processes. The reactor used for the research is a transparent cylinder made from acrylic, and effective capacities of headspaces of denitrification and nitrification filters are 2.07L and 1.30L respectively. Fluid flow was up-flow.

Vinylidene chloride in shape of loose loofah was used as the medium for anaerobic filter, while red-clay ceramic charged by about 90% of the total volume was used as the medium for nitrification filter.

Influent flow of this system is 0.02m^3/day, and HRT of the system is 4 hours(anaerobic EBCT 2.5h, aerobic EBCT 1.5h), and the system was operated with the gradual increase of recycle ratio and linear velocity which were adjusted between 0~3, 19.5~78m/d(0.8~3.25m/h). In consideration of carbon source necessary for biological removal process of nitrogen, industrial methanol, as external carbon source, was supplemented at the ratio of 4mg Methanol/mg TN [3]. Methanol was injected to influent pipe in order to prevent methanol from being denitrified in influent tank.

In this research, the effluent water for secondary treatment in sawage treatment plant "A" was used as influent water. Though properties and condition of sample changed according to the collection time of sample, average COD, TN, TP were 8mg/L, 16.9mg/L, 0.86mg/L respectively. The characteristics of influent water are summarized in Table 1.

TABLE 1
THE CHARACTERISTICS OF INFLUENT WATER

Parameters		System influent
pH	w/ alkalinity addition	6.8~8.0 (7.3)
	w/o alkalinity addition	6.4~7.1 (6.7)
	Overall period	6.4~8.0 (7.1)
Alkalinity ($mgCaCO_3/L$)	w/ alkalinity addition	86~208 (117)
	w/o alkalinity addition	30~64 (44)
	Overall period	30~208 (86)
DO (mg/L)		3.8~8.7 (5.5)
Temperature (℃)		21.5~26.9 (24.3)
Conductivity (ms)		374~752 (546)
SS (mg/L)		4.1~6.2 (5.4)
TCODcr (mg/L)		18~56 (28)
SCODcr (mg/L)		12~47 (25)
COD_{Mn} (mg/L)		9~11 (10)
TN* (mg/L)		13.9~19.8 (16.9)
Organic nitrogen (mg/L)		0.00~0.01 (0.01)
Ammonia* (mg/L)		5.4~12.8 (9.9)
NO_2^--N (mg/L)		0.00~0.01 (0.00)
NO_3^--N (mg/L)		5.8~11.7 (9.2)
TP (mg/L)		0.13~2.02 (0.86)

minimum ~ maximum (average)
* injection of additional ammonia nitrogen

All analytical measurements were performed as per procedures in the APHA Standard Methods [6].

III. RESULTS AND DISCUSSION

A. . Effect of Concurrent Injection of PAC and Alum on Removal of Organic Compounds

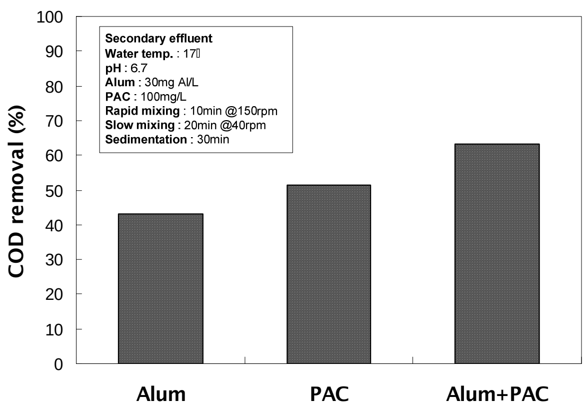

Fig. 1 Effect of Concurrent Injection of PAC and Alum on Removal of Organic Compounds

As a result of injection of PAC for removal of non-degradable organic compounds, removal efficiency of organic compounds was 52%. Meanwhile, as a result of concurrent injection of PAC and Alum, removal efficiency of organic compounds was 63%. These results suggest that Alum has no negative effect on adsorption of PAC, and is effective in improving treatment efficiency of organic compounds because it removes colloidal materials.

B. Effect of Concurrent Injection of PAC and Alum on Removal of phosphorus

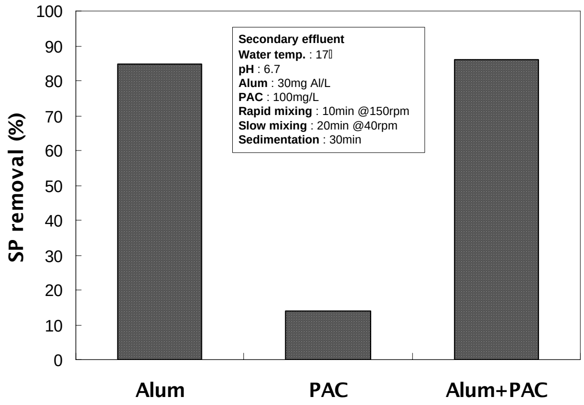

Fig. 2 Effect of Concurrent Injection of PAC and Alum on Removal of phosphorus

Alum was used as coagulant for removal of phosphorus. In the event that only Alum was injected, removal efficiency was 85%. Meanwhile, in case of concurrent injection of PAC and Alum, removal efficiency was 86%, which was similar to result of injection of Alum only. Therefore, it can be said that concurrent injection of PAC and Alum has no negative effect on removal of phosphorus.

C. Effect of Alum on alkalinity

Consumption of Alum was actually more than expected because Alum, as coagulant, was used for removal of phosphorus, and was affected by alkalinity of influent water and has incidental reaction with various salts. In particular, as decrease of alkalinity decreases has an effect on nitrification during biological treatment process, alkalinity should be considered.

$$Al_2(SO_4)_3\cdot 14H_2O + 2H_2PO_4^- + 4HCO_3^-$$
$$\rightarrow 2AlPO_4 + 4CO_2 + 3SO_4^{2-} + 18H_2O$$

However, in this system, the lack of alkalinity didn't reduce nitrification efficiency, and so, it can be said that supplementation of alkalinity is not necessary for this system.

D. Effect of PAC on Methanol

In consideration of carbon source necessary for biological removal process of nitrogen, industrial methanol was additionally injected as external carbon source, and so, it was found that methanol was not adsorbed by PAC.

E. Effect of Concurrent Injection of PAC and Alum on Removal of color and turbidity

In case of concurrent injection of PAC and Alum, turbidity and chromaticity were less than 0.1NTU and 5~10 degrees respectively, and met criteria for use of sewage.

F. Characteristics of Chemical sludge

Chemical sludge is generally discharged from a small settling basin in the lower part. Though some unsettled chemical sludges are flowed into anoxic tank, they are captured by anoxic medium. As a result of research, it was found that captured chemical sludge doesn't have an effect on denitrifying bacteria and denitrification efficiency. However, in the event that chemical sludge continuously flows into the medium, it may be a direct cause of reduction of backwashing period. Moreover, frequent backwashing may reduce denitrification efficiency, and so, inflow of chemical sludge should be prevented. In addition, it has been reported that re-elution of phosphorus doesn't occur in chemical sludge [7], and the same result was obtained in this research.

G. efficiency of the system

TN and TP efficiency of the system were 70% and 73% respectively, and insignificant amount of As, B and Zn were also removed. Tabel 2. is criteria for reuse of agricultural water, and results of comparison between influent and effluent water.

TABLE II
CRITERIA FOR REUSE OF AGRICULTURAL WATER, AND RESULTS OF COMPARISON BETWEEN INFLUENT AND EFFLUENT WATER

Parameters	Agricultural water	Secondary effluent	Lab-scale effluent
pH	5.8~8.5	6.4~8.0 (7.1)	6.3~8.3 (7.5)
BOD	<8	15.3	<3
DO	>2	4.1~8.2 (5.5)	3.8~8.7 (5.6)
Color	<20	10~15	5~10
Coliform group(count/100ml)	<200	7000	13800
Chloride(mgCl/L)	<250	57.1	53.6
TN(mg/L)	<10	13.9~19.8 (16.9)	4.7~7.5 (6.1)
TP(mg/L)	<1	0.13~2.02 (0.86)	0.02~0.17 (0.08)
ABS(mg/L)	<1	ND	ND
Al(mg/L)	<5	0.05	8.06 *
As(mg/L)	<0.05	0.08	0.05
B-total(mg/L)	<0.75	0.96	0.43
Cd(mg/L)	<0.01	ND	ND
Cr^{+6}(mg/L)	<0.05	ND	ND
Co(mg/L)	<0.05	ND	ND
Cu(mg/L)	<0.2	ND	ND
Pb(mg/L)	<0.1	ND	ND
Li(mg/L)	<2.5	0.01	0.01
Mn(mg/L)	<0.2	ND	ND
Hg(mg/L)	<0.01	ND	ND
Ni(mg/L)	<0.2	ND	ND
Se(mg/L)	<0.02	ND	ND
Zn(mg/L)	<2	0.03	0.02
CN(mg/L)	ND	ND	ND
PCB(mg/L)	ND	ND	ND

Effluent water of this system satisfied criteria for reuse of agricultural water and count of coliform group. It is necessary to remove coliform bacillus and reduce the injection volume of Alum. If coliform bacillus is removed, the water may be reused as water for cleaning, urban landscape and industry.

IV. CONCLUSIONS

High-efficiency integrated filter system is the process through which organic matter, nitrogen and phosphorus may be efficiently removed. Research and development on this system were conducted for reuse of sewage water. PAC and Alum used for removal of non-degradable organic compounds and phosphorus had no negative effect on chemicals. Organic compounds was, moreover, effective in increasing treatment efficiency. Methanol injected as external carbon source did not react with PAC. Despite of low C/N ratio, denitrification efficiencys were high. Though injection of Alum reduces alkalinity, it has no effect on nitrification, it is not necessary to increase alkalinity additionally. Chemical sludge didn't have an effect on biological treatment, but inflow of lots of chemical sludges into denitrifying basin may reduce backwashing period of denitrifying basin. Effluent water of this system had problems concerning removal of coliform bacillus and reduction of injection volume of Alum, but met criteria for reuse. I'll have a plan to research addition of membrane process into the latter part of process for removal of coliform bacillus, and reduction of injection volume of Alum.

ACKNOWLEDGEMENT

This paper was supported by Korea Minister of Ministry of Land, Konkuk University BK21 Program and Transport an Maritime Affairs(MLTM) as U-City Master and Green Technology Co., Ltd. in 2009.

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