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BAF와 연계한 응집.침전공정에 의한 정수처리 특성
Characteristics of Coagulation-Flocculation-Sedimentation Process with BAF Process on Drinking Water Treatment using Nakdong River Water

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<요 약>

최근에 경제성장과 생활향상에 따른 물수요량이 급증함과 동시에 소비자의 질적요구가 강화되고 있는 실정이다. 기존 상수원인 하천의 수질오염으로 인하여 소비자의 요구사항을 충족시키기 위해서는 기존 정수처리법의 개선이 요구된다. 따라서 본 연구에서는 기존 급속여과법의 전염소 처리공정 및 응집.침전공정의 개선을 통하여 음용수 수질을 개선하고자 하였다. 전염소 대신에 적용한 생물막여과 공정(BAF)의 처리효과 및 응집.침전 공정의 경우는 교반강도에 따른 침전효과에 따른 수질특성을 조사하였다. BAF공정은 탁월한 NH_4-N의 제거를 통하여 후속공정에 대한 오염부하량을 저감시킬수 있었고, 응집.침전의 경우 본 연구에서 제안한 응집제 주입량에 따른 교반강도의 실험식인에 의하여 구한 최적교반강도를 응집공정에 적용시 응집.침전의 효과를 향상시킬 수 있어 음용수 수질 향상을 기대 할 수 있었다.

1. Introduction

A sudden increase of populations and upgrade of living standard in our country through economic growth from 1970's later, it increased water demand for industrial facilities and livelihood, and resulted in the production of a great quantity of wastewaters, such as domestic sewage, industrial and agricultural-livestock wastewater.[1]

On the other hand, the most municipal wastewater treatment plants are primary and secondary treatment plants which consists of screening, grit removal, primary clarification, activated sludge treatment, and chlorination for the effluent disinfection, and in general,it removes a suspended solids and limited organic matters.[2),3)]

The discharge of these wastewaters composed a toxic and nonbiodegradable substances not

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adequately treated by the existing wastewater treatment plants have gradually aggravated the contamination of the river water, which has been being used as the water supply source.

Ammonia with greater than 3 mg/L is toxic to fish and the presence of nitrates in wastewater are undesirable because they are nutrients that stimulate algal and aquatic growth.[4),5)]

Accordingly, in recent, for people healthy and water environmental protection, the governemtal regulations for drinking water standards for water treatment plants and effluent standards for wastewater treatment plants have been strengthened.

This has required an increase and an upgrade of water and wastewater treatment methods. On the contrary, the existing rapid filtration system consisting of pre-chlorination, coagulation-sedimentation, sand filtration, and disinfection processes, which has largely removed suspended colloids substances.

It indicates that the existing system depending on physicochemical treatment has not appropriated in producing the water of good quality regardless of the variation of the contaminant levels. This has been resulted in the requirement to cope with the increasing water demand with good quality through the upgradation of the existing system by applying optimum operating conditions to each process and by introducing high-rate processes, which can be removed contaminants such as ammonia nitrogen (NH_4-N), alkylbenzensulfonate(ABS),potassium permanganate ($KMnO_4$) consumed, trihalomethane (THM) precusors, and so on, causing a trouble in purifying the water by the existing system.

This research was performed to reduce the contaminant levels of the influent using biological aerated filter (BAF) and the upgradation of the sedimentation and sedimentation processes by finding out the optimum operating conditions of the processes.

Therefore, the objectives of this study were to evaluate the characteristics of the BAF and coagulation - flocculation - sedimentation processes on the reduction of contaminants, through the determination of optimum values of velocity gradient and flocculation time with coagulant dosage.

2. Experimental Apparatus and method

Fig.1 shows a schematic of the BAF and coagulation - flocculation - sedimentation(CFS) processes. The BAF reactor was made of transparent acrylic column of Φ93mm and length 3,000mm to observe inner condition of it and was packed with a ceramic media with the effective size of 3.5mm up to the depth of 1,300mm. Underdrain plate supports the media and distributes the water and air to backwash when the headloss in the reactor was occurred. Air diffuser was located at about 100mm above the underdrain plate.

The CFS process consists of rapid mixing chamber of L120×W120×H150mm, flocculation basin of L235×W250×H250mm, and sedimentation basin of L1,450×W250×H350mm, which was made of transparent acrylic plate as all of rectangular basins to observe inner condition of it.

The basins of flocculation and sedimentation are separated by a acrylic baffle fence with numerous ports, which distribute the water inleted from the flocculation basin uniformly across the sedimentation basin. A weir in the sedimentation basin is used which spills into the effluent flume and extends across the entire width of the basin.

Rapid mixing employs vertical-shaft rotary mixing devices such as turbine impeller with a straight blade mechanical mixing basin is not affected to any extent by variation in the flow rate and have low headlosses for the following sand filter.

The mechanical agitators in the flocculation basin is a vertical-shaft paddle wheel as shown in Fig.1. Flocculation basin was designed to provid for tapered flocculation in which the flow was subjected to decrease velocity gradient, G as it passes through the flocculation basin.

through a pipeline the water passed the settling sand basin in the intake pumping station at the Nakdong river basin and was not pretreated by chlorine.

Characteristics of influent quality is given in Table 1.

This research is composed of two steps. The first step is to investigate the effect of the BAF process to reduce the level of contaminants for the following process.

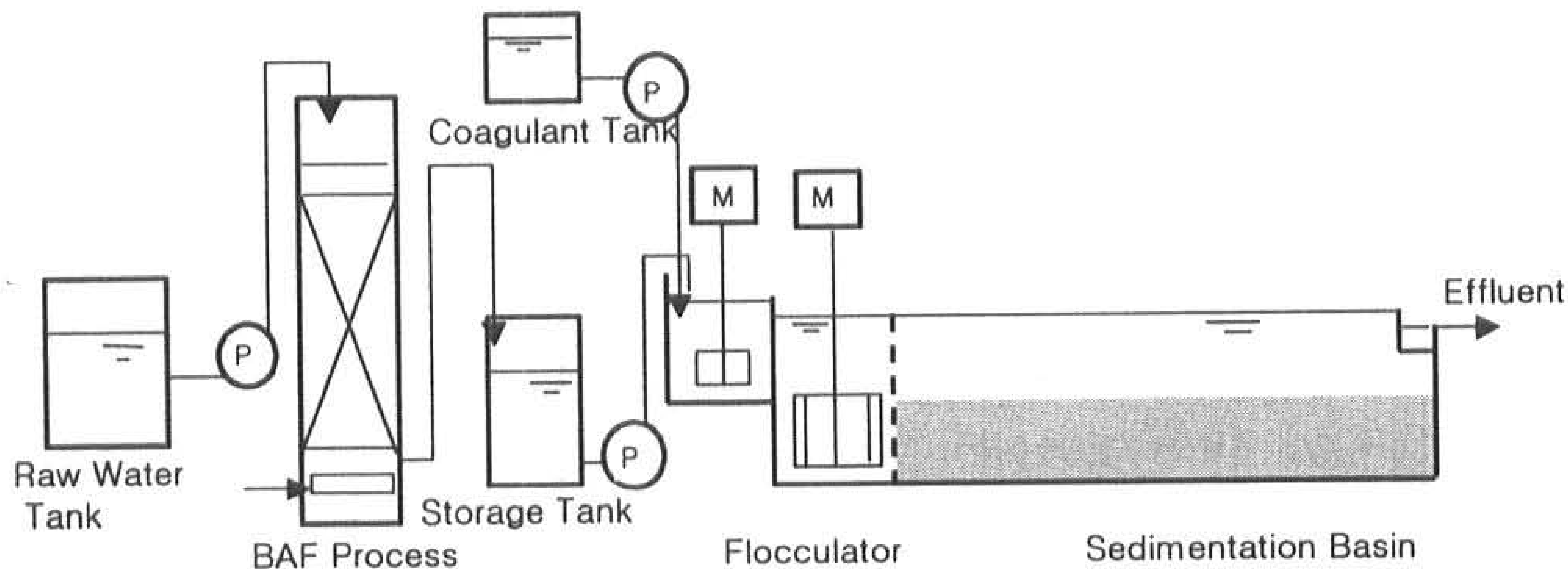

Fig. 1 A schematic of Coagulation-Flocculation-Sedimentation Process with BAF process

Table 1. Characteristics of the Influent Qualities

Parameter	Range
Water temp.(℃)	13~19
pH	6.9~7.4
Turbidity(NTU)	7~9
BOD_5 (mg/L)	3.5~6
SS (mg/L)	6~13
$KMnO_4$	14~20
consum(mg/L)	0.5~1
NH4-N (mg/L)	0.05~0.08
Mn (mg/L)	18~23
Color(unit)	

Raw water used during this research was the water of the Nakdong river transported

The BAF experiment was carried out at the flow rates of 100-120 m/day and air supply of 1.8-2.3 Nl/min. Air was supplied through the diffuser at the bottom of the filter bed.

At steady-state condition of the bAF reactor, samples were collected through sampling ports installed in the reactor at 200mm intervals from the upper of the reactor.

Backwash was initiated by reaching to critical operating level, 800mm from the surface of a packed bed and then was done at a interval of 2 weeks.

After backwashing, the lowest water level above the packed bed was 300mm, At the time, backwash air and water application rayes used were 3.5L/min and 4L/min, respectively.

The second step is to improve the efficiencies of the CFS process by optimizing the operation condition of it according to the variation of influent qualities.

The laboratory technique of the Jar-test was used to determine the proper coagulant dosages. In this test, samples of the water were poured into a series of glass beakers.

Coagulant used in this experiment was aluminum sulfate ($Al_2(SO_4)_3$), which frequently used as a coagulant to coagulate suspended solids and colloidal, and is feeded by diaphragm pump.

Table2 lists operational conditions of Jar-test as batch test, which was carried out to determine an appropriate ranges of flocculation time, velocity gradient (G), and alumnium sulfate (alum) dosage and to obtain optimum G value from redidual turbidity after settling for the raw water and the water filtrated by th ebiofilm filter.

The velocity gradient was computed by the following equation developed by T.R. Camp (1955)[6] to be applicable for mechanical or pneumatic agitation.

$$G=\sqrt{W/\mu}=\sqrt{P/\mu V} \qquad (1)$$

here, G : velocity gradient (sec^{-1})

W: power imparted to the water per unit volumn of the basin ($kg/cm^2.sec$)

P: power imparted to the water ($kg/cm^2.sec$)

μ: absolute viscosity of the water ($kg.sec/cm^2$)

Table3. lists the operating condition of the flocculation and sedimentation process. The influent is controlled by distribution basin, which is to keep a constant detention time in sedimentation basin.

Table 2. Operation condition of Jar-test

pH:7.1±0.1 Water Temp.:18-20℃, Turbidity:8-10ntu, Sedimentation Time: 10min

Run No.	G value (sec^{-1})	Flocculation Time (min)	Alum dosage (mg/L)
1	10-60	10-80	10
2	10-60	10-80	20
3	10-60	10-80	30
4	10-60	10-80	40

In water quality analyses, the samples were collected after each process and during each phase of experimentation, and the following parameters were quantified: pH, turbidity, dissolved oxygen (DO), 5 days-biological oxygen demand (BOD_5), suspended solids (SS), NH_4-N, ABS, color, $KMnO_4$ consumed, manganese (Mn). The analyses for all the above were performed according to Standard Methods[7].

Table3. Operational condition of Flocculation-sedimentation process

pH:7.1±0.1 Water Temp.:18-20℃, Turbidity:4.5-7.5ntu, Alkalinity(as $CaCO_3$): 37-45 mg/L

Item	Rapid mixing basin	Flocculation basin	Settling basin
Detention time(min)	3.40	35	220
G (sec^{-1})	150-200	18-50	-

3. Results and Discussion

Table4 summarized the results treated by the BAF process under the operating condition given in Table1. As shown in Table4 the removal rates of BOD and NH_4-N were 35 to 60% and more than 90%, respectively. For

DO concentration, both influent and effluent presented the value closed to the saturated concentration. Also, the removal of turbidity and SS ranged from 35 to 40% and from 40 to 50%.

Table 4. Water quality characteristics of th BAF process

Parameter	Influent	Effluent	Removal Rate (%)
Temp.(℃)	13-18	13-19	-
pH	6.9-7.5	7.1-7.6	-
DO (mg/L)	7-9	8-10	-
Turbidity(ntu)	5-10	3-6	35-50
SS (mg/L)	5-11	2-5	40-60
BOD (mg/L)	3.2-5.9	2.3-2.9	36-60
$KMnO_4$ Cons.	14-20	10-14	27-30
NH_4-N	0.2-0.5	0-0.02	90-100
Color	18-23	13-18	20-30

Fig.2 indicates the relationship between residual turbidity and velocity gradient with flocculation time in the case of run 3 given in Table2. In this experiment, the G values used ranged from 19 to 45 1/sec at flocculation time of 10-80min. The results showed that the optimum G value increased in proportion as the flocculation time decreased. Under flocculation time of 35 min and alum dosage of 40 mg/L, the optimum velocity gradient was all about 30 1/sec regardless of both the water with and the one without pretreatment by the BAF process and for residual turbidity, that after pretreatment was lower 0.3 NTU than that before pretreatment.

Plotted the experiment results shown in Fig.2 on log-log graph for runs, the relationship between the optimum G value and flocculation time is shown in Fig.3, which indicates that the four lines have the same incline without regard to coagulants dosage. Using the graph the following equation is given:

$$2.7 \log G* + \log T = \log K \qquad (2)$$

here, G* : optimum velocity gradient(1/sec)

T : flocculation time (min),

K : constant (-)

Applied antilog to equation (1), the optimum G value is given:

$$(G*)^{2.7}\ T = K \qquad (3)$$

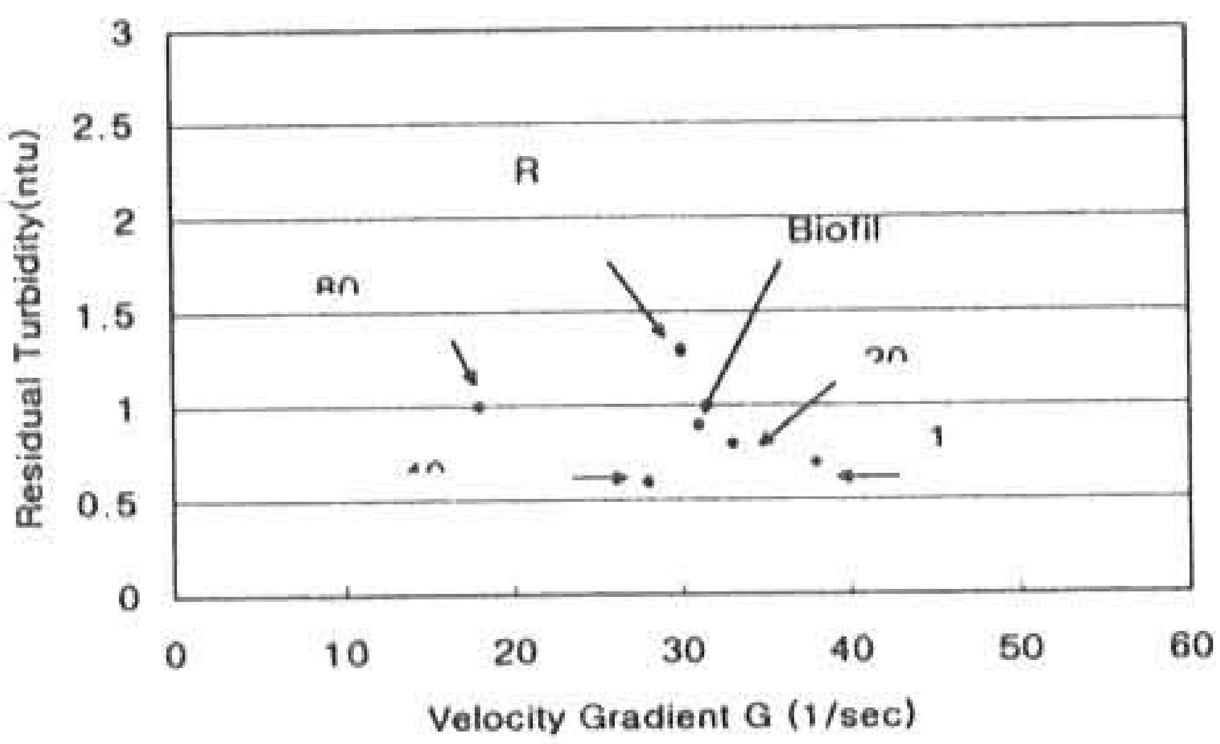

Fig. 2 Turbidity versus G value for flocculation basin

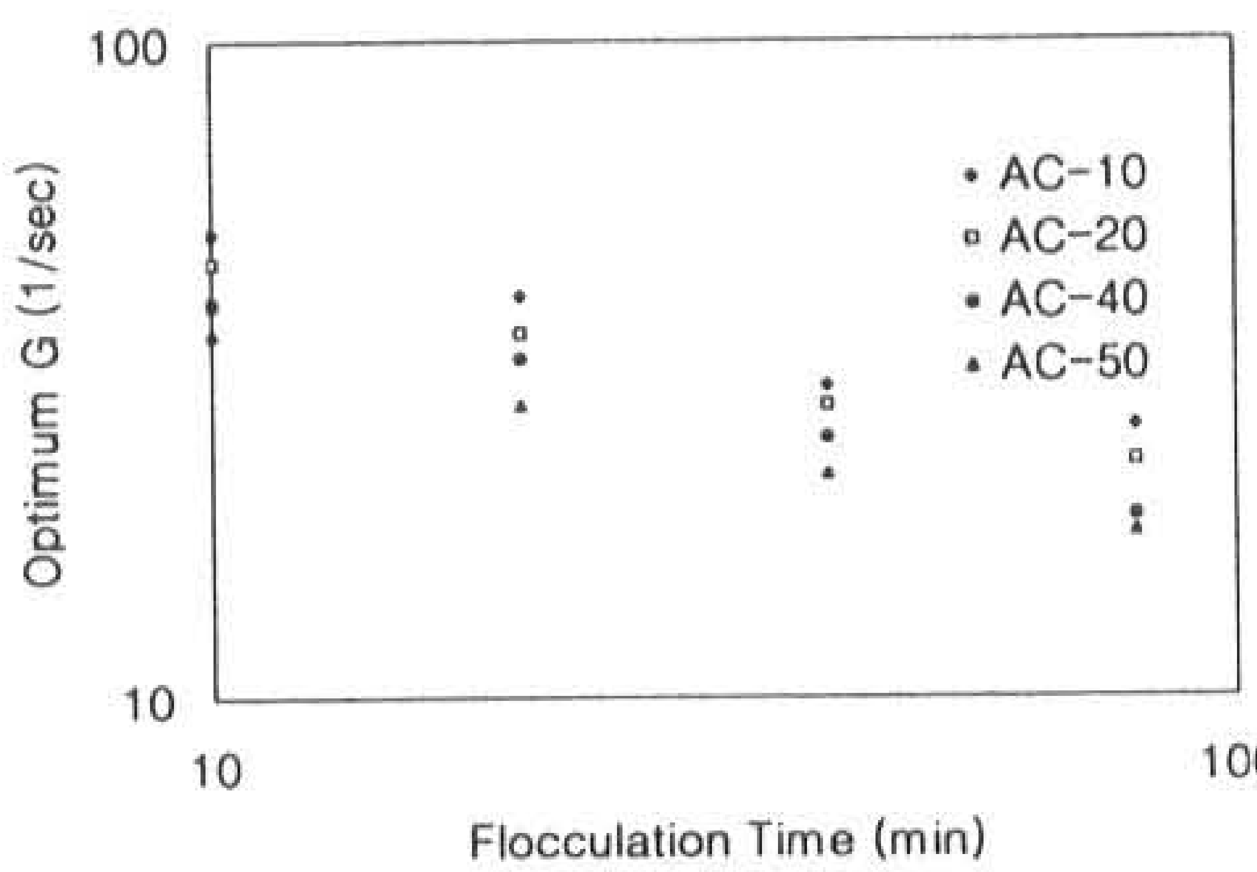

Fig. 3 Optimum G value versus flocculation time(AC: alum concentration)

This equation yields the optimum values for velocity gradient, G and flocculation time, T as K value is given : therefore, the G and T values determined by K value can be applied when design the flocculation process.

Fig.4 shows the profiles of K and alum concentration. The values for K at alum dosage of 10-50 mg/L were 4.1×10^5 and 1.6×10^5, respectively. This indicates the optimum G value decreases in proportion to increase of alum concentrations.

As for the turbidity removal in sedimentation basin, compared the alum amount obtained from Jar-test with the one from K, it is shown in Fig. 5 that the alum amount given by K value is better than the one by Jar-test.

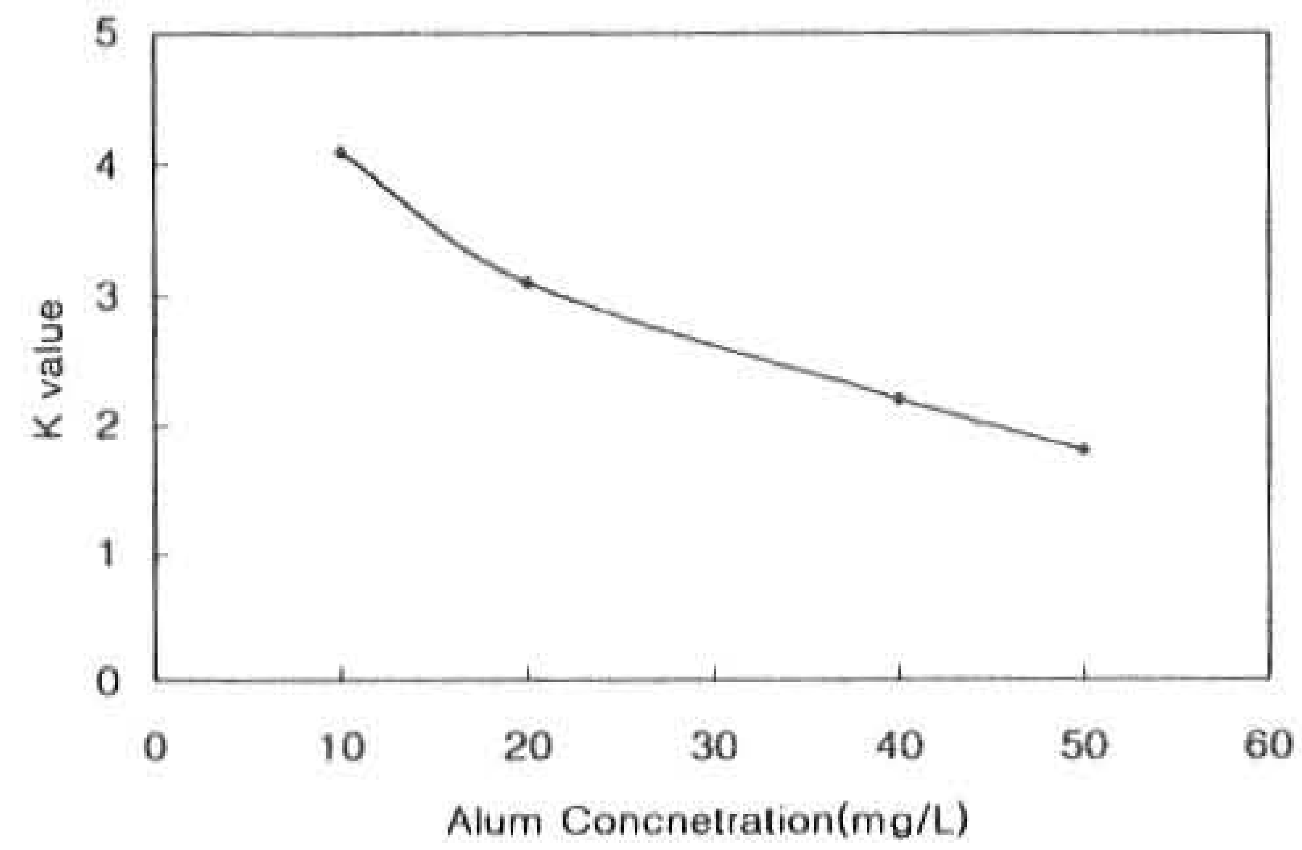

Fig. 4 K versus alum concentration

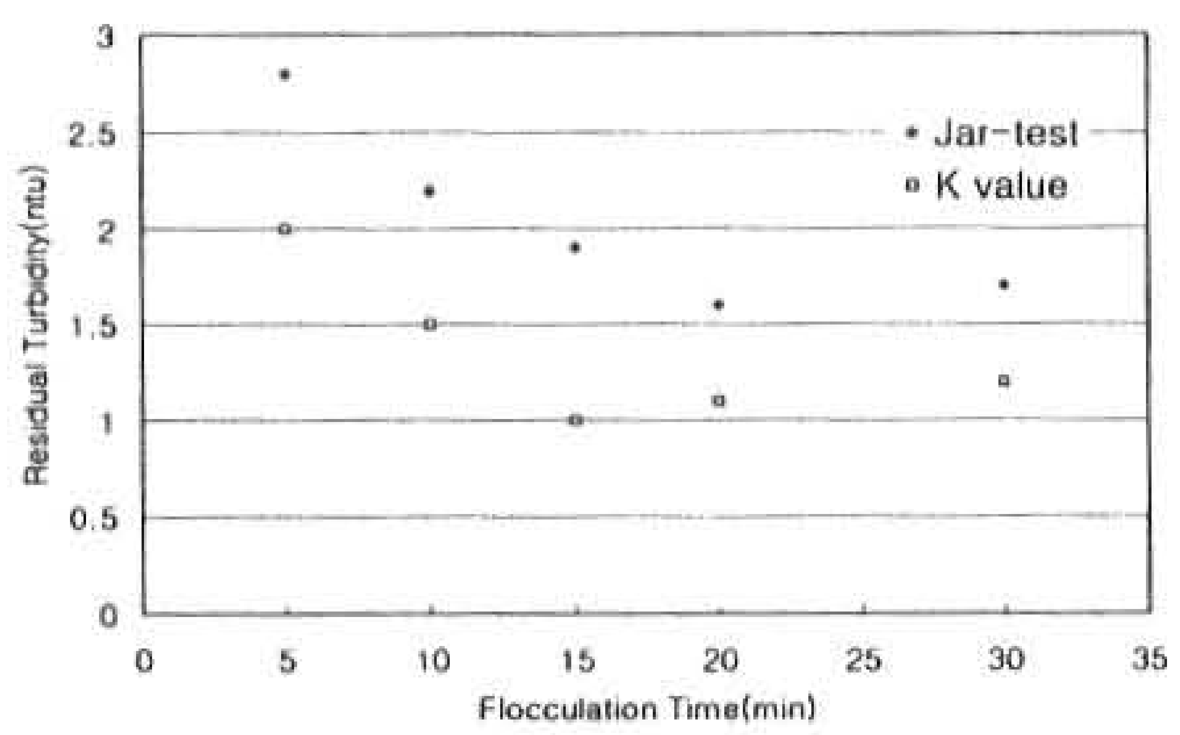

Fig. 5 Residual turbidity versus flocculation time

4. Conclusion

In order to improve the operating characteristics of the flocculation - sediment - ation process with the biofilm filter, this study was carried out at Water Treatment Plants located at Nakdong river basin. Based on the results obtained from this experiments, the biofilm filter could be effectively reduced ammonia nitrogen and turbidity, so that the effluent from the biofilm filter could be upgraded the efficiencies of flocculator and sedimentation basin. For the flocculation and sedimentation experiment, the optimum velocity gradient increased in proportion as the flocculation time decreased and the residual turbidity after pretreatment was lower 0.3 NTU than that before pretreat-ment.

The relationship between velocity gradient and flocculation time could be expressed as follow : $(G*)^{2.7}T=K$

The K value was important parameter for decision of optimum alum dosage and design of flocculation basin. the alum dosage by K value was more effective than the one by Jar-test as to turbidity removal in sediment-ation basin.

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