연속 DAF공정을 이용한 휴믹물질의 전처리 조건의 영향

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Effect of pretreatment condition of humus laden water in continuous DAF process

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Introduction

Dissolved air flotation (DAF) is an effective solid/liguid separation process for low density floc particles, such as algal floc, humus materials and clay particles produced from low turbidity water. It is a proven drinking water treatment technology in many European countries[1)]. The fraction of humic substances for natural organic matter (NOM) of low turbidity water are considered problematic in drinking water because it can readily react with chlorine to form harmful by-products (trihalomethanes) and can be exposed to undesirable color, tastes, and odors in drinking water[2),3),4)].

The DAF facilities are composed of the following four steps: (1) coagulation and flocculation prior to flotation, (2) bubble generation, (3) bubble-floc collision and attachment in a mixing zone, (4) rising of bubble-floc agglomerates in a flotation tank. This paper will discuss the results from a study that performed with batch experiment (DAF jar tester), which is determined step (1), and a continuous DAF pump process (DAFPP), which is determined step (2), (3), and (4), using synthetic low turbidity wastewater contained humic substance

Materials and Methods

Chemical reagents: Humic acid was obtained from the commercial humic acid (Sigma, USA) with composition C: 51.37%, H: 4.19%, N: 0.75%, as indicated by Marzet[5)]. Humic acid concentrations were used from 8.12mg TOC/L to 18.52 mg TOC/L. The coagulant used, Al2(SO4)318H2O, waspure or analytical grade. Stock solutions of the coagulant were prepared indeionized water. The coagulant solutions were prepared a day before from stock solutions, to avoid ageing phenomena and improve reproducibility. The coagulant concentrations were from 100mg Al_2O_3/L to 1200mgAl_2O_3/L.

Analytical methods: Aqueous carbon concentraions were measured with TOC analyzer (Shimadzu 5000A). TOC samples were prepared by acidifying to pH 2 with phosphoric acid and stripping with N2 gas to remove inorganic carbon prior to injection. TOC samples were filtered through pre-rinsed glass filter units (GF/C) prior to acidification, stripping, and analysis. UV absorbance was measured from 400 nm to 800nm using a spectrophotometer (Lambda 20, Perkin-Elmer Co.) and matched 1 cm quartz cuvettes.

DAF jar tester: A DAF jar tester (EC engineering) was used which hadthe facility to pre-set the stirring intensity and time. The paddle size of the tester was 3.05.0 cm2. The coagulation and flocculation conditions involved rapid mixing at 300 rpm (G value: $182.6s^{-1}$) for 60 s followed by slow mixing at 40 rpm ($21.1s^{-1}$) for 20 min. Recycle flow was 20 %.

Dissolved air flotation pump process (DAFPP): The experiments were carried out using a DAFPP, schematically shown in Figure 1. It is comprised of coagulation unit, flocculation unit, flotation unit, and DAF pump. The properties of DAF pump were shown in Table 1.

Table 1. Specification of domestic DAF pump

Flow rate	0.2 m3/min
Head	45 m
Moter power	7.5 HP
Impeller	ϕ 165 mm
Back vane	ϕ 250 mm

The coagulation and flocculation unit have 1 liter and 15 liters useful volume, respectively. The flotation unit has 100mm internal diameter, 800mm height, and useful volume of 8 liters. Operation conditions of influent were flow rate of 0.2 L/min and intial concentration (TOC) of 13.24 mg/L. In the coagulation and flocculation unit the speed of paddles could be varied and thereby also the velocity gradient, $G(s^{-1})$. The G value for optimum efficiency was $182.6s^{-1}$ in the coagulation and 21.1 s^{-1} in the flocculation unit. Recycle flow to the DAF pump varied between 20 to 50%.

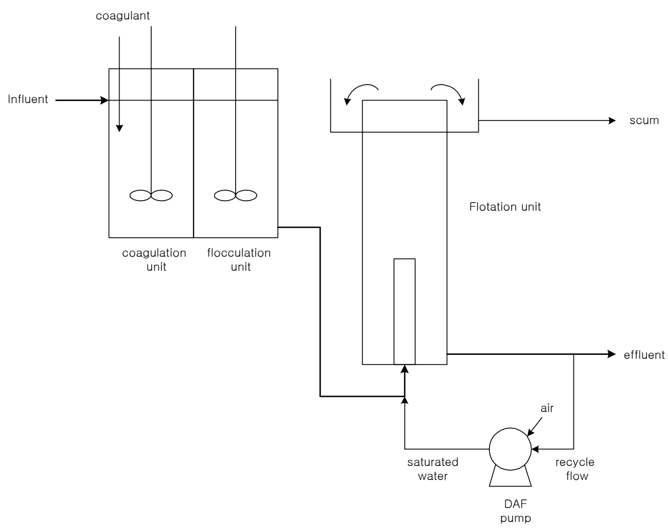

Figure 1. Systematic diagram of DAF pump process (DAFPP).

Results and Discussion

Batch experiments by the DAF jar tester: A DAF jar tester had been performed using alum to coagulate humic acid at pH 6.4. The results presented in Figure 2 indicate that the required dosages for the alum were determined by the content of residual TOC. Optimum coagulant dosages are determined by the various TOC concentrations. This result clearly indicated that the optimal dosage for TOC concentration of 8.12, 10.93, 13.24, and 18.52 mg/L were about 2.52, 3.36, 5.03, and 8.39 mg Alum/L conditions, which corresponded to about 60-70% removal. The relations of optimum alum dosages and TOC concentration were followed by the equation of [Alum] = 1.42[TOC] 3.70, R^2 =0.9713; [Alum] is optimum alum dosage (mg/L); [TOC] is humic acid concentration (mg/L); a and b are constant.

The results of Chun et al.[6] by coagulation and sedimentation experiments showed that coagulant dose more than these results by coagulation and flotation. The difference in alum dosages between flotation (DAF) and sedimentation was amplified because coagulated floc size, which was necessary for successful TOC removal in flotation, was smaller than sedimentation. The finding that removal of humic substance after coagulation and flocculation was dependent of optimum coagulant dosages was consistent with results presented by several researchers[2),6),7)]. The coagulation of humic substances by hydrolysing metal salts was described as co-precipitation, charge neutralization and/or adsorption mechanisms, depending on the coagulants dosage and humic substances concentration[8)]. The coagulation reaction of humic acid at pH 6.4 corresponded to the positively charged monomers ($Al(OH)_2^{+}$ or $Al(OH)^{2+}$) or solid amorphous aluminum hydroxide($Al(OH)_3$)[9)]. Here aluminum species hydrated represented negatively charged carboxyl group or phenolic OH group of humic acid.

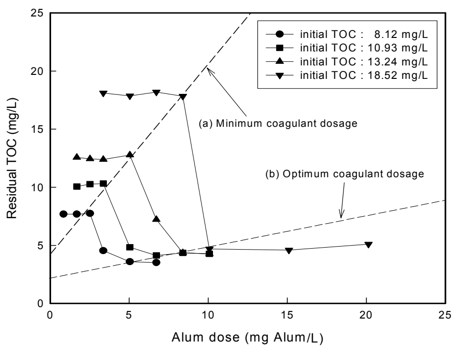

Figure 2. Influence of coagulant dose on TOC at pH 6.4 .

Removal efficiencies of humic acid by a continuous DAFPP: The coagulant dosages in a continuous DAFPP experiments were optimized based on preliminary DAF jar tests, and coagulant dosing rate was 1.8 mg alum/min. The removal efficiencies of humic acid were performed using a lab-scale unit designed by a continuous DAFPP. Figure 3 shows the effect of removal efficicncies of TOC on pump pressure. To produce water floated (removed humic acid) removal efficiency of 80 % or more, a recycle of 40 % was needed. The data show poor treatment less than 4kg_f/cm^2, but good treatment efficiency is achieved with 5kg_f/cm^2 over. Bubble size released decreased as the pump pressure increases. It appeared from this result that the removal efficiencies of humic acid increased because of bubble-floc attachment efficiency. Sander E. R. et al.[10)] described that the bubble size decreased with an increase in the saturation pressure, and the adhesion of air bubble and floc depended on the size of the bubbles and the size and the nature of agglomerated flocs.

Figure 4 shows that the performance of saturator type DAF and DAFPP are examined by comparing TOC. TOC of treated effluents decreased with increasing recycle ratio, although recycle ratio was 30% more over. The difference in performance of two systems is amplified because bubble size released, which is mean diameter of about 50 mm at 5.0 kg_f/cm^2, in DAFPP was smaller than saturator type.

Conclusion

The results obtained in this research permit us to conclude that the preliminary batch experiment (DAF jar tester) can be effectively used a continuous DAFPP. The optimal coagulation and flocculation conditions for humic acid was an aluminum concentration, which is followed by the equation of [Alum] = 1.42[TOC] 3.70, corresponding to sweep coagulation for supersaturation. Effect of pump pressure in DAFPP on the removal efficiencies of humic acid is achieved with $5kg_f/cm^2$ more over. Bubble size released decreases as the pump pressure increases. Finally, Studies of continuous experiment indicated that DAFPP produced significantly higher removal efficiencies than saturator type DAF.

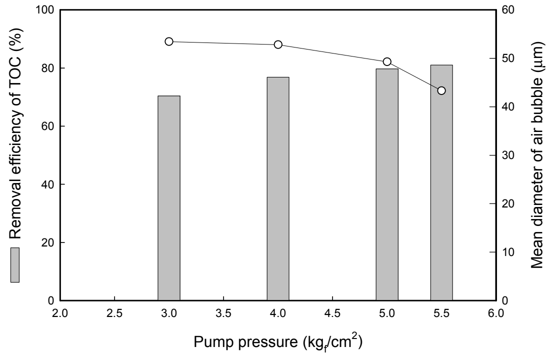

Figure 3. Effects of pump pressure on removal efficiencies of TOC.

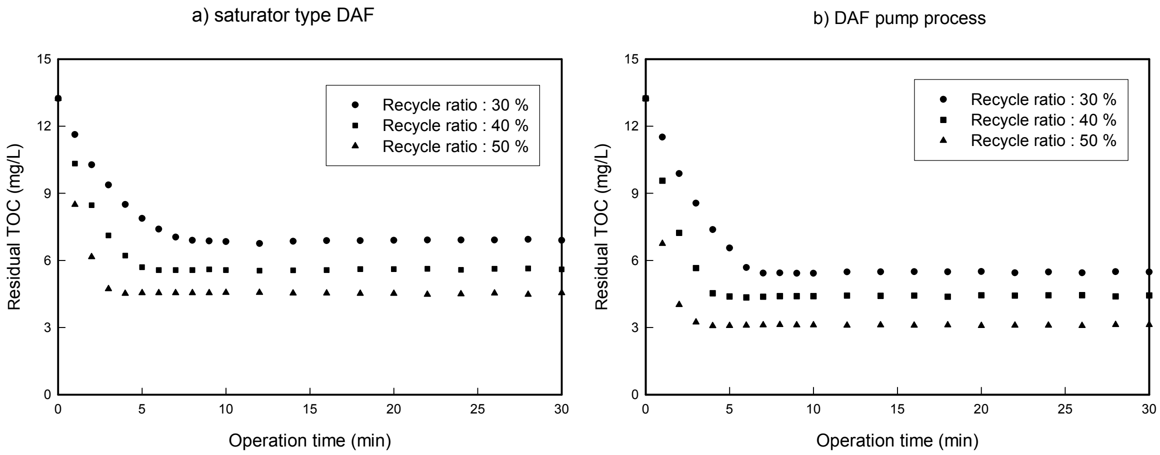

Figure 4. Comparison between saturator type DAF and DAF pump process.

References

1. Longhurst S. J. and Graham, N. J. D. (1987). Public Health Engineer. 14, 71-76.
2. Sang-Kyu Kam and John Gregory. (2001). Wat. Res. 35, 3557-3566.
3. S. Jansen et al. (1996). Materials Sci. & Eng. 4, 181-187.
4. C. R. O'Melia et al. (1999). Wat. Sci. Tech. 40, 47-54.
5. G. A. Edwards and A. Amirtharajah. (1985). AWWA. 77, 50-53.
6. Hee Dong Chun and Moon Deuk Lee. (1987). J. of KICHE, 25, 303-311.
7. C. R. O'Melia et al. (1999). Wat. Sci. Tech. 40, 47-54.
8. Jinmin Duan et al. (2002). Desalination 150, 1-14.
9. Chihpin Huang and Hueiling Shiu. (1996). Colloids & Surfaces, 113, 155-163.
10. San E. R. et al. (1994). Wat. Res. 28, 465-473.