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Coagulation of Secondary Wastewater Effluent by Aluminum Sulfate

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1- Introduction

During the past 20 years, an additional water treatment defined as advanced wastewater treatment is increasingly required to remove the suspended and dissolved matters, both organic and inorganic, remaining after conventional secondary treatment before rejection in the receiving water. Experimental studies with aluminum sulfate were carried out in order to investigate the removal of the turbidity and the soluble matters. The secondary effluent is from the activated sludge plant in Muroran city.

The objective of this study is to find the best conditions for coagulation of the soluble matters and sedimentation of the turbidity.

2- Coagulation Methods

An eight-beaker jar-tester was used and the experiments were performed with 500 ml beakers. A period of 5 minutes was allowed for rapid mixing at 120 rpm, followed by 30 minutes of flocculation at 50 rpm and 30 minutes of sedimentation. During these experiments, the coagulant was first added, then hydrochloric acid (HCl) and/or sodium hydroxide (NaOH) was added for pH correction. Aluminum sulfate ($Al_2(SO_4)_3.14\sim18H_2O$) was used as coagulant. Color, turbidity, CODcr, Fe and humic substances were measured. The pH was adjusted to 10 before color was measured.

3- Results and Discussion

According to **Table-1**, 1 mg/L of humic substances corresponds to the color of 25 to 30 mg Pt/L. The soluble CODcr represents 65% to 75% of the total CODcr and 65% to 70% of the color. The high residual color is due to the fact that color is biologically non degradable. In studies of colored streams by Black and Christman[1], high dissolved COD concentration and only traces of BOD were observed, suggesting that the organic matter responsible for color are resistant to biological decay. Shapiro[2] observed that yellow organic acids extracted from colored waters resisted microbial attack.

Coagulation of turbidity is plotted against pH in **Fig 1** for the secondary wastewater effluent and for the "suspension" of suspended solids extracted from the effluent and "resuspended" in the tap water. The optimum pH for turbidity coagulation in the case of the "suspension" ranges from 4 to 7 whereas for the secondary wastewater, it ranges between 5.5 and 6.

In **Fig 2**, the ratio C/Co is plotted against the pH for some compounds of the wastewater effluent. The coagulation of both, organic and inorganic matters is maximum in the pH range of 5 to 6. We can say that turbidity and soluble matters have the same optimum pH for coagulation. The same coagulation rate of 50% for color, humic substances and Fe suggests that stable humic-Fe complexes exist in the effluent[3].

Table-1:Characteristics of the wastewater effluent

Items	Concentration (mg/L)
Turbidity	5~15
Color	23~50
NH4-N	18~33
Phosphate	0.4~0.8
CODcr	22~45
Fe	0.05~0.12
Humic subs.	1.2~1.5
BOD5	8~11
Alkalinity	11~13
pH	7~8

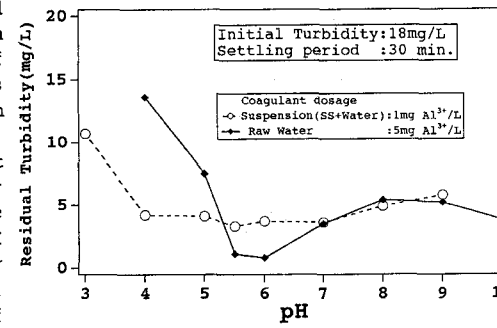

Fig 1:Effect of pH on turbidity settling

In **Fig 3**, the C/Co ratio is plotted against the coagulant dosages at pH of 5.5. The coagulation of color, CODcr and turbidity increases with an increase in the coagulant dosages. At the dosage of 6 mg Al^{3+}/L, 90% of the turbidity were coagulated against 60% and 25% for color and CODcr respectively. Coagulation of color by aluminum sulfate is limited to the extent of 60% to 70%.

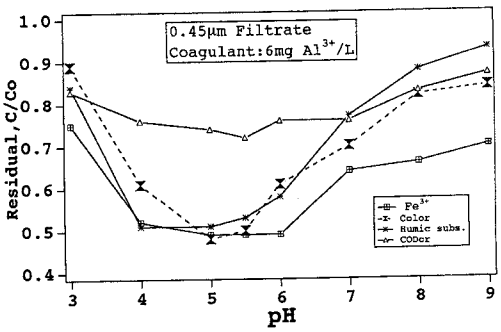

Fig 2:Effect of pH on wastewater content coagulation

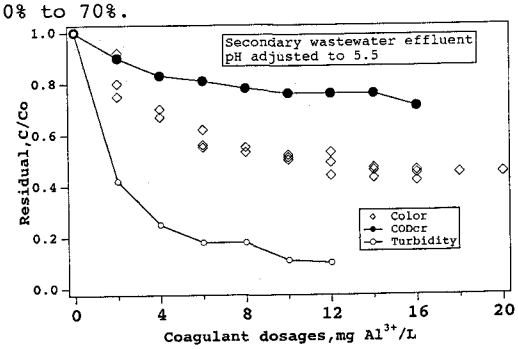

Fig 3:Effect of coagulant dosage on the removal of the wastewater content

Fig 4 shows the size distribution of color for 3 different coagulation dosages. At 4 mg Al^{3+}/L, 90% of the coagulated flocs were larger than 5 μm against almost 100% for 6 and 8 mg Al^{3+}/L because at higher dosages the flocs grow larger.

In **FIG 5**, the residual color is plotted against the pH for the 0.45 μm filtrate and for the supernatant at the dosage of 6 mg Al^{3+}/L. The supernatant was taken after a settling period of 30 minutes. In both cases, the coagulation is maximum in the pH range of 5 to 6. In the case of the supernatant, the residual color is of 55% against 50% for the 0.45 μm filtrate. The difference of 5% represents 10% of the coagulated flocs. Compared to the **Fig 4**, larger flocs were settled but only flocs slightly larger than 5 μm remained in solution.

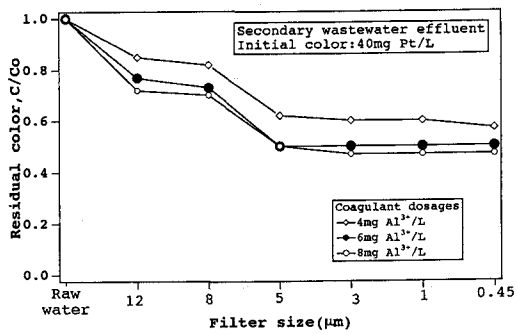

Fig 4:Color size distribution

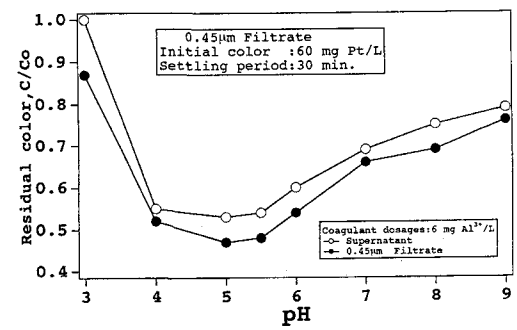

Fig 5:Effect of pH on color coagulation

4- Conclusions

1- Maximum coagulation of turbidity and soluble matters in the secondary effluent occurs in the pH range of 5 to 6.

2- Coagulation of color by aluminum sulfate is limited to the extent of 60% to 70%.

3- At higher dosages, almost 100% of the flocs coagulated grow larger than 5 μm.

References

1- A.P. Black and R.F. Christman: Chemical characteristics of Fluvic Acids. *Jour.AWWA,Jul 1963*

2- Shapiro J.: Chemical and Biological Studies on the Yellow Organic Acids of Lake Water. *Limnol.Oceanog.,2:161,1957.*

3- N.B. Tozan Michel, H. Hozumi, H. Yoshida and H. Ueda: Coagulation Properties of Secondary Waste water Effluent by Aluminum Sulfate. *Annual Conference of the JSCE-Hokkaido branch. February 1994.*