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Coagulation Properties of Secondary Waste Water 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. The standard of tertiary effluent quality proposed by the Ministry of Construction[1] is shown in **TABLE-1**. The characteristics of the secondary waste water effluent from the activated sludge plant in Muroran city are presented in **TABLE-2**.

To meet these requirements, experimental studies with aluminum sulfate was carried out in order to investigate the removal of the turbidity and the soluble matters, both organic and inorganic. The coagulation-assisted water treatment with aluminum sulfate is a cheap process compared with the other coagulants and treatment processes.

The objective of this study is to find the best conditions for coagulation of the secondary waste effluent i.e. the optimum pH for soluble matters coagulation and turbidity sedimentation.

Table 1:Standard of tertiary effluent

Items	Tertiary Effluent
Tot. Coli	50/100 ml
BOD(mg/L)	3
Turbidity(mg/L)	5
Color(mg/L)	5
pH	5.8~8.6

Table 2:Characteristics of the waste water 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
pH	7~8

2- Coagulation Methods

The experiments were carried out with three kinds of water:

- 0.45 μm filtrate waste water
- secondary waste water effluent
- Suspension of tap water and suspended solids extracted from the secondary effluent.

A 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. Before filtration, the membrane filter was washed with 100 ml of distilled water. During these experiments, the coagulant was first added, then, depending on each case, hydrochloric acid (HCl, 1N and 0.1N) and/or sodium hydroxide (NaOH, 1N and 0.1N) was added for pH correction. Aluminum Sulfate ($Al_2(SO_4)_3.14\sim18H_2O$) was used as coagulant. Color, turbidity, CODcr, BOD_5, Fe and humic substances. In this study, humic substances were taken without distinction of the different compounds.

The pH was adjusted to 10 before color was measured in order to hydrolyze the color-aluminum complexes because at that value and depending on the coagulant dosage, the sample recovered its initial color concentration with a dispersion ranging between 4% and 6%.

Color and humic substances were measured by the photometer at the wavelength of 420 and iron at 520 nm.

3- Results and Discussions

The sediments obtained from the activated sludge by centrifugation were dried at 105 °C and then incinerated at 500 °C. The sediments consist of approximately 75% of organic matter and 25% of inorganic matter.

Residual turbidity is plotted against pH in **Fig 1** for two kinds of water. Suspended solids removed from the secondary waste water effluent and "resuspended" in the tap water and the secondary waste water. The optimum pH for turbidity settling in the case of the "suspension in tap water" ranges from 4 to 7 whereas for the secondary waste water, the optimum pH ranges between 5.5 and 6. Maximum coagulation of soluble organic matters that occurs in the pH range of 5 to 6 may have shifted the pH for maximum settling of the turbidity to the range of 5.5 to 6. Settleable flocs combined with flocs enmeshed on the turbidity have improved the removal efficiency. Almost 95% of turbidity sedimentation occurs in that pH range[2].

In **Fig 2, 3, 4, 5 & 6**, the effect of pH on the coagulation of soluble matters was investigated. The maximum coagulation of the soluble matters occurs in the pH range of 5 to 5.5.

In **Fig 2**, the coagulant dosages of 6 and 8 mg Al3+/L have almost the coagulation efficiency whereas in Fig **3, 5 & 6** the coagulation efficiency increases with an increase in the coagulant dosage.

In **Fig 2 & 3**, the pH values of 5 to 5.5 give the optimum coagulation for CODcr and color because their residual concentration is the lowest.

In **Fig 2**, the residual color is almost constant regardless of the coagulant dosages. Whereas in **Fig 3**, CODcr coagulation increases with an increase in the coagulant dosage. *The dosage of* 6 mg Al^{3+}/L was taken as the optimum for color coagulation because at higher dosages the difference in residual color represents only 1 to 2 mg Pt/L.

From **Fig 2**, we can see that coagulation of color ranges betweem 60% and 70%.

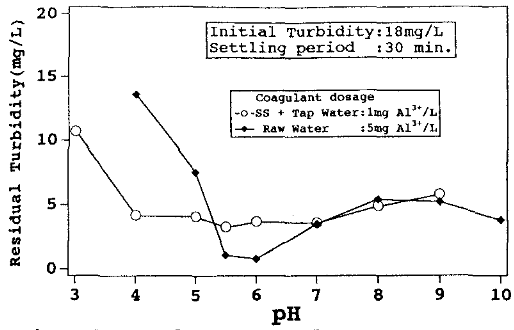

Fig 1:Effect of pH on turbidity settling

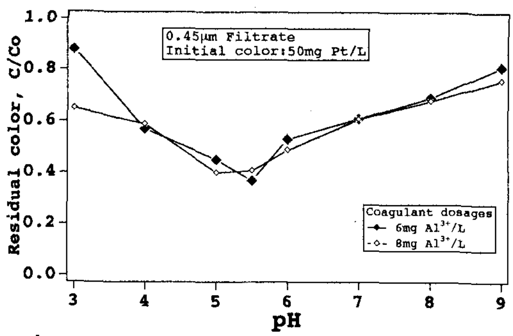

Fig 2:Effect of pH on color coagulation

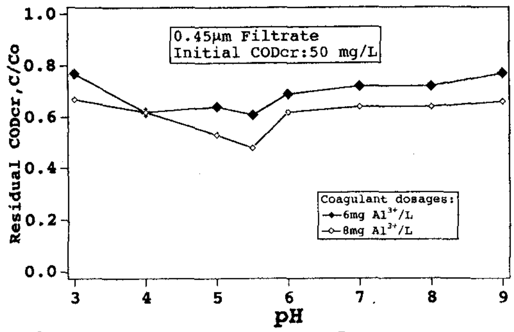

Fig 3:Effect of pH on CODcr coagulation

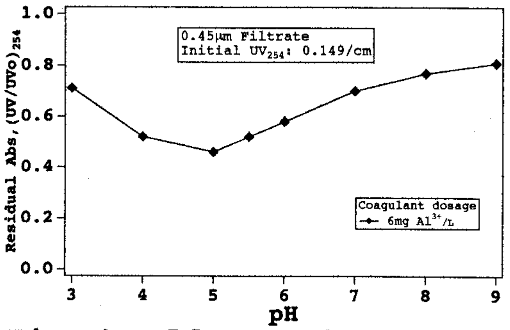

Fig 4:Effect of pH on UV_{254} absorbance

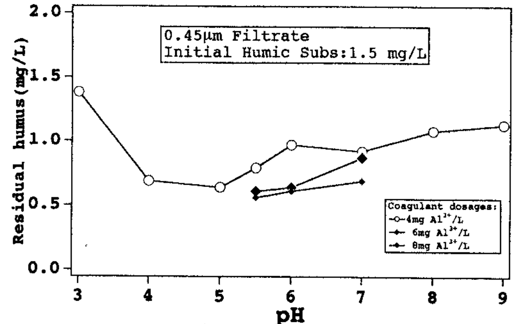

Fig 5:Effect of pH on Humic substances coagulation

In **Fig 3**, the coagulation of CODcr ranges from 40% to 50%. The difference of coagulation between color and CODcr is due to the fact that CODcr consists of carboneceous such as organic color and non carboneceous organic matters. It is generally believed that color is biologically non degradable. In studies of colored streams by Black and Chrisman[3], high dissolved COD concentrations and only trace amounts of BOD were observed, suggesting that the organic matter responsible for color are resistant to biological decay. Furthermore, Shapiro[4] observed that yellow organic acids extracted from colored waters resisted microbial attack.

The humic substances in **Fig 5** and Fe in **Fig 6** have the same optimum pH coagulation because they may exist as humic-Fe complexes.

From **Fig 7**, residual color UV_{254} absorbance is plotted against the coagulant dosages at the pH value of 5.5. The coagulation of color by the aluminum sulfate seems to reach the maximum between 60% and 70% of the color content. Color in waste water is caused mainly by the humic substances and also by the inorganic compounds such as iron and manganese. The organic fraction i.e. consists of phenolic and carboxylic groups. The coagulation of this fraction depends on the molecular weight of the different compounds of the humic substances. Though coagulation occurs with an increase of the dosage, 6 mg Al^{3+}/L may seen as the optimum dosage.

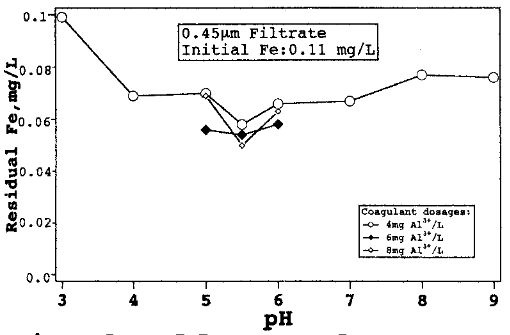

Fig 6:Effect of pH on Fe coagulation

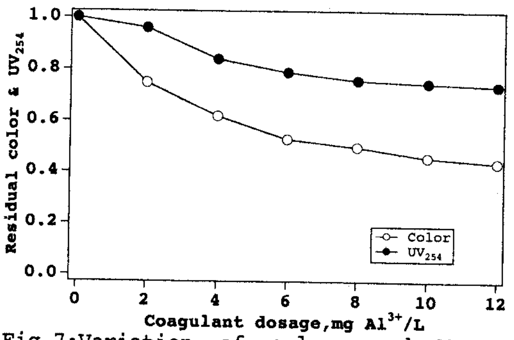

Fig 7:Variation of color and UV_{254} absorbance with coagulant dosage

4- Conclusions

1- The sedimentation of turbidity is maximum in the pH range of 4 to 7. In the secondary waste water, the sedimentation of turbidity is influenced by the coagulation of dissolved matters. The pH for maximum sedimentation was shifted to the range of 5 to 6 by the settleable of dissolved organic matters precipitated by the coagulation.

2- Coagulation of color, iron, CODcr, humic substances and PO_4^{3-} are maximum in the pH range of 5 to 5.5.

3- The coagulation of color in the waste water effluent by aluminum sulfate is limited to the extent of 60% to 70% of the initial content.

References

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2- N.B. Tozan Michel, H.Hozumi, H.Yoshida and H.Ueda:Direct Filtration of Secondary Waste Water Effluent by a Dual Media Filter. Proc. of Env.Engr. Research. Vol.30, 1993. pp267~273.

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