A Study on Coagulation of Turbidity and Color in Leachate from a Sanitary Landfill

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1. Introduction

The latest revision of the Japanese guideline for municipal solid waste landfill became effective since June of 1998, and states about maintenance and management control criteria of landfill. Analysis of the quality of the landfill final effluent should be often done (over 4 times in a year), and it should suit, throughout 2 years, the following maximum limits: 60 mg/l for SS and BOD and 90 mg/l for COD[1].

Leachate quality is an indicator of landfill stabilization. Besides, if the landfill contains hazardous substances, its leachate can contaminate the surrounding soil, the groundwater and/or the nearby water bodies. Therefore, frequent landfill condition inspection should be done through leachate quality analysis and leachate must undergo proper treatment before being discharged to the environment.

Since color and turbidity in water are due to natural organic matter, which in turn is composed largely of humic substances, it can accumulate hydrophobic organic compounds, including dioxins and the like. The purpose of this study is then trying to optimize the actual leachate treatment in order to achieve a satisfactory removal efficiency of coloring matter and turbidity. Thus, COD, humic substances (humic and fulvic acids), turbidity, and SS parameters have been analyzed, as well as its removal concentration ratio through the application of coagulation-sedimentation tests,

2. Experimental Methods and Conditions

2.1 Raw leachate characteristics

The waste disposal area in study is located in the Southern part of Hokkaido and landfilling has started since November of 1994. In general, it is composed of incombustible waste and incineration residue. Nevertheless, business incombustible waste usually contains a considerable amount of organic waste. Further, during the incineration plant inspection period, which is accomplished once a year, in the course of one month, all the combustible waste is carried directly toward the waste disposal facility, consequently increasing the amount of organic substances in the landfill.

Sample was taken from the exit extremity of the leachate collection pipes and its characteristics are listed in table-1.

Table-1 Raw leachate quality

pH	6.9～7.4
COD	23.5～88.0 mg/l
Color (humic acid)	29.0～109.0 mg/l
Turbidity	4.5～68.0 mg/l
Fulvic acid	3.4～11.0 mg/l
SS	2.3～76.3 mg/l

2.2 Coagulation sedimentation test

An eight-beakers jar-tester was used for the coagulation-sedimentation tests. Ferric chloride ($FeCl_3 + 6H_2O$) was used as coagulant. After addition of coagulant, the solutions were first undergone rapid mix at 120 rpm during a period of 5 minutes, followed by 30 minutes of flocculation at 50 rpm and left for 30 minutes for sedimentation. Actually, at first, the sedimentation time was set as 30 minutes, then longer intervals were also tried, such as 1hour, 2 hours and 3 hours. Since no significant improvement on the removal concentration could be observed, 30 minutes sedimentation will be taken as reference throughout this study.

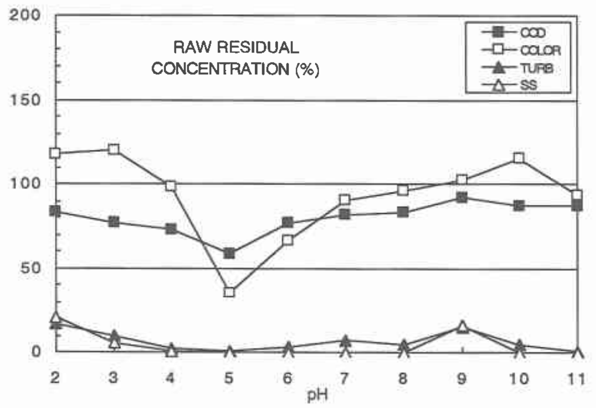
The first coagulation-sedimentation test trials had the purpose to find out the optimum pH value for the concentration removal of COD, humic acid (considered as color), fulvic acid, turbidity and SS. Thus, adjusting various pH values, within a range of 2 and 11, and adding a fixed coagulant concentration, the samples were set up for the coagulation-sedimentation test. Paralleling to it, after finding out the optimum pH value, a second stage was also accomplished. But in this case, the optimum pH was fixed and the coagulant concentration varied. Among a range of 10 mg/l to 500 mg/l, different concentrations were put on trial.

3. Results and Discussion

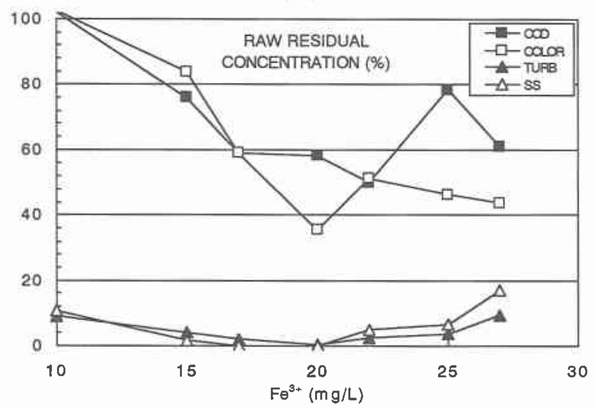
From the accomplished experiments, it could be observed that the highest removal efficiency for all parameters was reached under the conditions of a pH 5 and a coagulant concentration of 20 mg/l (or near it), as it can be seen in figure-1.

It can be observed from figure-1(a) that pH data outside a 5 ～ 8 range showed over measured color residual concentration. The dimension of the humic substances molecules varies with the pH, consequently the color parameter will depend on the pH of the sample. As a rule, as lower as the pH of a sample was, the higher was its color value. On the other side, for a high alkaline solution, color tended to increase.

Among the coagulant concentration range applied (10～500 mg/l), color showed a better removal efficiency for low Fe^{+3} concentration (around 20 mg/l). The same could be observed for turbidity and SS parameters. In general, turbidity and SS concentrations could be completely removed (100% removal efficiency) using 20 mg/l of Fe^{+3} (figure-1(b)). In fact, humic substances (fulvic acid analysis started later, during autumn) didn't show a good response for very high coagulant concentration, which could be observed for values of 50 mg/l of Fe^{+3} and higher. In such cases, the residual concentrations used to be over 100%, which has no meaning for the present study. Such overdose response might be due to the influence of the coagulant's own coloring matter. COD presented good removal efficiency for low coagulant concentration (around 20 mg/l). But under a high coagulant concentration condition (i.e. 500 mg/l), COD could also be efficiently removed, which turned to be its optimum point for concentration removal. Considering the numbers, in general, the best COD removal efficiency didn't reach over 59%. For color, the best value becomes 75%, and for fulvic acid it is 70%.



(a)



(b)

Figure-1 Raw residual concentrations for (a) different pH values at a fixed coagulant concentration of 20 mg/l, (b) different coagulant concentrations at a fixed pH 5. Sampling period: summer. Raw sample quality: COD=88.0, color=108.1, turbidity=42.7 and SS=59.5 (unit: mg/l)

A next stage of experiments is related to the leachate concentration seasonal variation. It could be observed that COD, humic substances, turbidity and SS values decreased with the forthcoming winter season. Due to the leachate low concentration, and after confirming the optimum pH (i.e. pH 5), a new trial coagulation-sedimentation test was applied.

From figure-2, a reduction in the optimum coagulant concentration can be observed especially for color and COD parameters, which had not showed a good response for a coagulant concentration of 10 mg/l in the previous experiments, as it could be seen in figure-1(b). In figure-2, considering color and turbidity parameters, it can be clearly seen that its optimum coagulant concentration has dropped from 20 to 10 or 5 mg/l. On the other side, COD concentration optimum removal efficiency was still reached using 20 mg/l of Fe^{+3}, but it presented a very small difference (around 3%) among 10 and 20 mg/l of coagulant applied. Except for 25 mg/l of Fe^{+3}, which presented a response of over dosage (i.e. residual concentration ratio over 100%), SS could be completely removed for all the other cases of coagulant concentration addition. Fulvic acid, whose analysis was included later, following the same tendency for the color parameter, showed its best removal efficiency when 10 mg/l of Fe^{+3} was used.

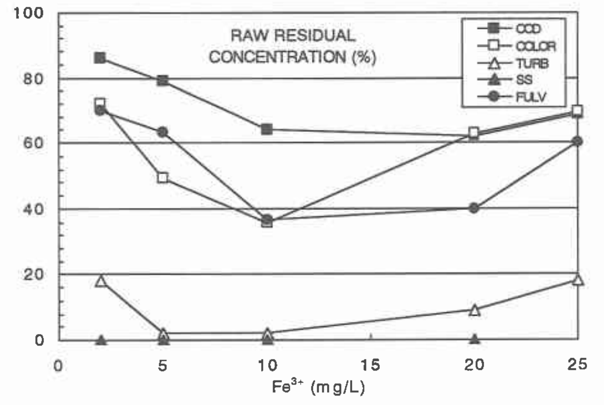


Figure-2 Raw residual concentrations for different coagulant concentrations at a fixed pH 5. Sampling period: winter. Raw sample quality: COD=23.6, color=29.0, turbidity =4.5, SS=2.2 and fulvic acid=3.4 (unit: mg/l)

4. Conclusions

In principle, as a rule, the highest removal efficiency for all parameters was reached under the conditions of a pH 5 and a coagulant concentration of 20 mg/l (or near it).

However, with the approaching winter, raw leachate quality has presented a decrease in the analyzed parameters concentration values. This fact has led to a deviation of the optimum coagulant dosage, whose most significant cases are represented by color and turbidity, with a drop from 20 to 10 or 5 mg/l of Fe^{+3}.

Still, few data has been collected, but if this tendency can be confirmed, and considering the long winter seasons under which the area where the landfill is located goes through; a reduction in the amount of addition of coagulant can be a good advantage. Once the necessary concentration of coagulant to reach the optimum removal efficiency can be reduced, an economy in the cost for the leachate treatment is evident.

Acknowledgment

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References

1) Research Group of Technical System of Waste Disposal Site: **Handbook of Technical System of Waste Disposal Site**, Kankyo-Shinbunshya, pp. 667-669, 1999.

2) Yamada H. et al: **Development of Treatment System for Removing Dioxins from the Landfill Leachate**, Proceedings of the Asian Pacific Landfill Symposium of the Japan Society of Waste Management Experts, pp. 384-390, 2000.

3) Osako M. et al: **A Study on Behavior of Persistent Organic Pollutants in the Landfill Site with Municipal Solid Waste Incineration Residue**, Proceedings of the Asian Pacific Landfill Symposium of the Japan Society of Waste Management Experts, pp. 397-403, 2000.