Effectiveness of volcanic ash soil flocculant for muddy water treatment

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Introduction

When soil is excavated during construction, mining industry operation and other municipal industries, rain water picks up soil particles and carry them to nearest water body. The larger particles, such as pebbles and sand, will fall quickly to the bottom once the flow rate slows. However, clays and fine silts particles tend to stay suspensions because they settle slowly. As a result, turbidity extends far away in streams and make ponds and lakes muddy. Turbidity reduces the biological productivity of the affected water, decreases the recreational value of the water area and increases water treatment costs for industrial or drinking water plants. The purpose of flocculant is to treat muddy water so as to make suspended clay and fine silt particles settle quickly. The purpose of this paper is to assess the effectiveness of volcanic ash soil flocculant for muddy water treatment base on the flocculation tests of soil suspensions.

Material and Method

Onjaku (weathered basalt soil) and Maaji (red soil in Okinawa) were used for the tests. Table 1 shows the chemical properties of the soil samples. Onjaku possesses greater CEC than Maaji.

Two types of flocculant were used for flocculation tests: the one artificially produced from volcanic ash soil (referred as VAS hereafter) and poly aluminum chloride (PAC),

Clay fraction (<5μm) were used for flocculation tests. The original soil of 50g was added to 150mL water and shaken for 12 hours, and the suspensions were adjusted to pH 10 for dispersion. The suspensions were put into 1L cylinders and the clay fractions were collected based on the stoke's law. The clay suspensions thus collected were adjusted to solid concentrations with the range of 0.1-12g/L, and flocculation tests with addition of flocculant were conducted on the suspensions in 100mL cylinders. Several sets of clay suspensions with the same solid concentration were prepared and different amount of flocculant were added to each of the suspensions to determine the minimum amount of flocculant that cause flocculation. After agitation of the clay suspensions, they were left to stand to observe whether sharp boundary appears between supernatant and gel due to settlement of flocs and supernatant become clear. And then the minimum of amount of flocculant that make the supernatant clear was determined.

The setting speed of flocs in suspensions was assesses using the suspensions (solid concentration of 2g/L) with different amount of flocculant by measuring time for flocs in the suspensions to settle completely and supernatant becomes clear.

Table 1 Exchangeable cation and cation exchange capacity (CEC)

Soil	CEC ($cmol_c$/kg)	Exchangeable cation ($cmol_c$/kg)			
		Na	K	Mg	Ca
Maaji	10.16	0.32	0.33	0.93	3.00
Onjaku	33.05	0.54	0.33	2.14	1.29

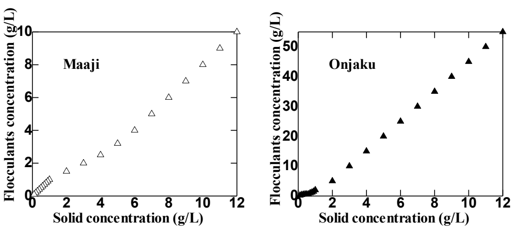

Fig.1. Relation between the solid concentration and the volcanic ash soil flocculant (VAS) concentration needed for flocculation of soil suspensions.

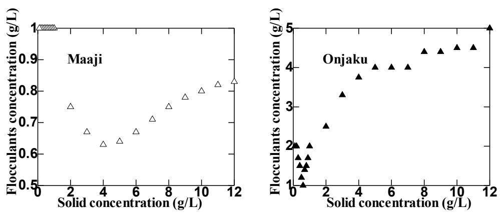

Fig. 2. Relation between solid concentrations versus volcanic ash soil flocculant (VAS) per unit soil weight for the flocculation of soil suspensions.

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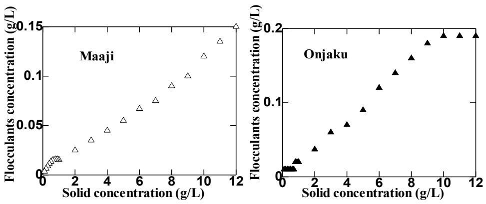

Fig. 3. Relation between solid concentrations versus polyaluminium chloride flocculant (PAC) concentration needed for the flocculation of soil suspensions.

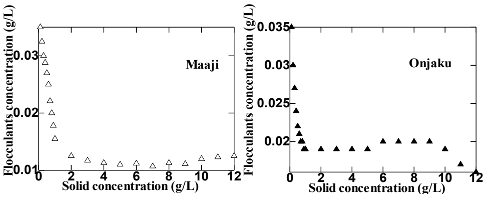

Fig. 4. Relation between the solid concentrations versus polyaluminium chloride flocculant (PAC) per unit soil weight for the flocculation of soil suspensions.

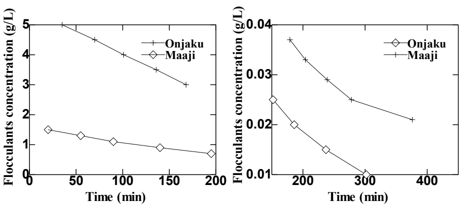

Fig. 5. Time for setting of flocculants at different flocculant concentration.

Results and discussions

Figure 1 shows the characteristic of flocculation via addition of VAS. The amount of flocculants added increased almost linearly with increasing the solid concentration for both soils. The VAS would carry both positive and negative charges (Wada, 1977) as the pH of the clay suspensions was in the range of 6.4 to 7.9. This led to flocculation through attraction between the positive charged surface of VAS and negative charged clay particles. More amount of VAS was needed for flocculation in Onjaku than Maaji because of the greater CEC for Onjaku than Maaji. Greater CEC carry more negative charge on clay particles.

Figure 2 indicates the amount of VAS per unit soil mass needed for flocculation. The amount of VAS for flocculation increased with decreasing solid concentration below 4g/L for Maaji and 0.6g/L for Onjaku. This would be lesser chances for VAS to attach to clay particles in lesser particle density, thereby the requirement of more VAS to be added. The mininmun amount of VAS for flocculation was seen for both soils, being 0.63g/g-soil for Maaji and 1g/g-soil for Onjaku. This amount of VAS would carry the minimum positive charge that can neutralize negative charge on the clay particles. Beyond the solid concentration of 4g/L and 0.6g/L, the amount of VAS for flocculation increased with increasing solid concentration.

Figure 3 shows the characteristic of flocculation via addition of PAC. The amount of PAC added for flocculation increased almost linearly with increasing the solid concentration for both soils. Much difference in the amount of PAC added was not observed between the two soils unlike the case for VAS in fig.1. The charges on the clay particles in suspension are destabilized by the addition of PAC and flocculation occurred. The clay particles adhere to each other via Al^{3+} on the surface of the particles, thereby merging individual clay particles. This result in larger, denser flocs that settle more rapidly.

Figure 4 indicates the amount of PAC per unit soil mass needed for flocculation. The amount of PAC for flocculation increased with decreasing solid concentration below 1g/L for both soils. This would be due to lesser chances for PAC to attach to clay particles in lesser particles density, thereby the requirement of more PAC to be added. The amount of PAC for flocculation was almost constant beyond the solid concentration of 2g/L.

Figure 5 shows the relation between the flocculant concentration in the suspension and the time for flocs in the suspension to settle completely. The speed for the setting of flocs decreased with decreasing flocculant concentration for both VAS and PAC and for both soils. The setting speed of flocs was greater for VAS than PAC.

Conclusions

For the flocculation of soil suspensions, more amount of VAS was needed for Onjaku than Maaji. The setting speed of flocs was greater for VAS than PAC, and decreased with decreasing flocculant concentration for both VAS and PAC.

References

Wada, K. 1977. Allophane and imogolite. In J.B Dixon et al. (editors). Minerals in Soil Environments. Soil Science Society of America.