8.1 Introduction

Poly aluminum silicate sulphate (PASS) is a patented product [Haase et al., 1991] recently introduced in Canada and Europe for water treatment [Arnold-Smith et al., 1992]. It is produced by a combination of aluminum sulphate, sodium aluminate and sodium silicate, all materials traditionally used in water purification. Since it is a partially hydrolysed polymeric product of aluminium in the liquid form, it is expected to produce dense flocs very fast. A few trials using the material described in literature have demonstrated its applicability in European countries in water below 16°C, the effectiveness reportedly decreasing at higher temperatures. But there are no reports on its efficacy in water from countries with much higher ambient temperatures like India. Several other composite flocculants have also been developed with the hope of obtaining a better performance compared to any single, conventionally used flocculant [Nishizava and Fukui (1996), Hu and Zhou (1999)].

PASS is described in literature as having the average composition

$$\text{Al}_A(\text{OH})_B(\text{SO}_4)_C(\text{SiO}_X)_D(\text{H}_2\text{O})_E$$

where $A = 1.0$, $B = 0.75-2.0$, $C = 0.3-1.12$, $D = 0.005-0.1$, $X = 2.0-4.0$ and $E$ is larger than 4. It is an aqueous solution containing about 9% Al estimated as $\text{Al}_2\text{O}_3$ and a density of 1.25 to 1.30 g cm$^{-3}$.
Cochin Minerals and Rutiles Limited (CMRL) is a rutile processing industry in Edayar near Cochin. A waste slurry containing titanium dioxide fines, ferric chloride and HCl is generated in the process and poses a disposal problem to the industry. The fines settle on keeping and the supernatant is an acidic, yellowish solution containing about 4% iron (w/v as Fe$_2$O$_3$). This liquid shall be called “Fe-solution” in all subsequent discussions in this chapter. Ferric chloride is also a flocculant conventionally used in water treatment plants.

PASS and the Fe-solution described above were examined for their flocculation efficiency using kaolinite suspensions, and for removal of colour due to polyphenols in water that has been used for coir retting (see section 1.6). Efficacy of the materials in removing kaolinite turbidity and colour due to polyphenolics in water was compared with that of alum under similar conditions.

### 8.2 Materials and methods

#### 8.2.1 Polyaluminium silicate sulphate (PASS)

PASS was prepared in our laboratory using commercial alum used in water treatment, sodium metasilicate, scrap aluminium turnings and NaOH flakes. The method of preparation was as follows:

1. About 100 g of powdered alum was stirred with 200 mL of water in a beaker and kept for two days. The supernatant was filtered to obtain a saturated solution of alum, coloured light brown due to the presence of traces of iron.
(2) A saturated solution of sodium metasilicate in 30 mL of water was prepared and filtered.

(3) About 13 g of NaOH flakes was dissolved in 130 mL water and cooled to ambient temperature in a suitable round-bottomed flask. Approximately 7 g of aluminium turnings was added into it. Vigorous reaction ensues with liberation of hydrogen, and the flask is kept cooled in running tap water till the reaction subsides. The solution of sodium aluminate is filtered immediately through a fluted filter paper. As this solution will gel on keeping, it has to be prepared immediately before mixing the components.

About 102 mL of solution (1) was taken in a 1 L beaker and stirred mechanically while cooling in an ice bath. Solution (2) was added to it, dropwise, till about 21 mL was consumed. Stirring the mixture was continued and 65 mL of solution (3) was added to it dropwise over a period of 40 min. The liquid mixture containing PASS was allowed to reach ambient temperature and stored in a glass bottle. Density = 1.3 g cm⁻³, pH = 3.5, Al₂O₃ = 8%. Since some sediment slowly forms on standing and increases on keeping, the shelf life of the product is limited.

8.2.2 Fe-solution

Slurry containing TiO₂ fines, iron and HCl was obtained from Cochin Minerals and Metals Limited, Edayar. It was kept undisturbed for two days, the supernatant decanted out and stored in a glass bottle. Density = 1.0 g cm⁻³, pH = 1.7, Fe₂O₃ = 4% (w/v).
8.2.3 Kaolinite suspensions

Prepared as under section 3.2.1.1 in chapter 3.

8.2.4 Model coloured water

Coconut husks from ripe coconuts were soaked in water in a fibreglass tank for two months. The water coloured reddish brown due to the polyphenolic materials leached out from the husks was used in the experiments.

8.2.5 Jar tests

Tap water as obtained was used as suspension medium and no attempts to adjust the pH of the suspensions were made during these tests. The suspensions were mixed rapidly for 5 min after adding the flocculant solutions using a syringe, followed by slow stirring at 60 rpm for 15 min. Stirring was then stopped and allowed to settle for 60 min. The supernatant was withdrawn from 5 cm below the surface using a pipette for taking measurements. pH was measured before and after the jar tests to note any change. In the case of kaolinite, suspensions with an initial turbidity of about 65 NTU on an average was used; the initial and final turbidities were measured as described under section 3.2.1.4 in chapter 3. In the case of coloured water, the colour was measured using a spectrophotometer by noting the absorbance at 430 nm where it showed maximum absorption; a higher value for absorbance indicating a deeper colour. The coloured water was diluted with tap
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Figure 8.1.

Change in pH of kaolinite suspension of initial pH 7.2 produced by adding various amounts of test substances.
Figure 8.2.

Effect of various dosages of test substances on the residual turbidity

(Kaolinite suspensions of 65 NTU initial turbidity, pH = 7.2)
produces the lowest residual turbidity at dosages below 15 mg L\(^{-1}\), but loses its effectiveness totally at higher dosages. The effectiveness was also noted to decrease below 5 mg L\(^{-1}\). Since the Fe-solution produces the lowest residual turbidity at a very low dosage of 5 mg L\(^{-1}\) with the least change in pH of the water (see Figure 8.1), and being an industrial waste material, considerable savings can be obtained by its application in clarifying water or waste water.

8.3.3 Removal of colour due to polyphenolics

The effect of various dosages of the test substances on the colour of water due to dissolved polyphenolics is summarised in Figure 8.3. At dosages up to 15 mg L\(^{-1}\), all the substances tested showed a tendency to deepen the colour. But there was a big difference among their behaviour above this dosage. At a dosage of 30 mg L\(^{-1}\), both alum and PASS produced flocs very quickly. But on settling, the water treated with alum had lost all its colour while there was almost no change in the colour of water treated with PASS. On the other hand, there were no flocs in water treated with Fe-solution. The colour intensified and changed to a dark blue probably due to oxidation and complex formation between iron and the polyphenolic compounds.
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Figure 8.3.
Change in colour of water used for retting coir when treated with various dosages of test substances
8.4 Conclusion

The results show that both PASS and the byproduct ferric chloride were more effective than alum in removing kaolinite turbidity. PASS produced a denser floc with a lesser sludge volume. The byproduct gave the lowest residual turbidity using a lesser concentration of the flocculant. Both PASS and the byproduct produced treated water with pH closer to neutral than when alum was used. This can lead to a reduction in treatment costs (1) by using an industrial byproduct at comparatively lower dosages instead of alum, and (2) by reducing the quantity of lime required for correcting the pH of water after treatment to acceptable levels.

However, alum was found to be most effective in removing the colour of water used for retting coconut husks. The colour was almost completely removed as indicated by spectrophotometric analysis.