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Dewatering of Water Treatment Plant Sludges Using Polystyrene and Polymethylmethacrylate

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The water treatment plant sludges are mainly composed of lime and alum. It can not be dried on the sand beds because of the poor drainability of raw sludge. Chemical conditioning generally improves the sludge characteristics like specific resistance and coefficient of compressibility. The present article deals with the application of certain synthetic polymers like polystyrene (PS) and polymethylmethacrylate (PMMA) for conditioning the sludge. Their effects on sludge characteristics have been presented. The variation in the specific resistance and coefficient of compressibility have also been studied under three different sets of pH conditions.

Key Words: Dewatering, Water treatment, Plant sludges, Polystyrene, Polymethylmethacrylate.

INTRODUCTION

The draining of the water treatment plant sludge over the sand bed is not effective owing to penetration of solids through it. The water associated with the sludge particles poses a great problem due to poor drainability. The separation of water from the sludge can be achieved by coagulation of water by chemical conditioners. Polymers of wide nature, mainly synthetic and natural type, have been widely used to coagulate the sludge particles. Mainly they are either of cationic or anionic type. The present study was undertaken to evaluate the use of polystryrene and polymethylmethacrylate both nonionic type for improving the characteristics of chemical sludges. The lime-alum sludge was obtained from the Kilpauk water treatment plant, Chennai.

Specific resistance (r) and compressibility (s) are two basic characteristics that determine the sludge performance on sand beds. Specific resistance is the internal resistance of sludge cake to the passage of water and it is a measure of the filtering rate of sludge. The coefficient of compressibility (s) gave an idea about the filtration characteristics of the sludge. It should exceed 0.7 units to avoid frequent sand replacement and also to get a direct filtrate discharge[1, 2].

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EXPERIMENTAL

The brown coloured sludge obtained from Kilpauk water treatment plant, Chennai was a lime-alum sludge. The pH varies between 9.8 and 10.2. The specific resistance of the raw sludge is 24.707×10^9 sec^2/g at 72.8 cm of Hg and coefficient of compressibility is 0.46.

Determination of 'r' and 's'

The polymer polystryrene and polymethylmethacrylate were prepared as per the standard procedure and dissolved in 10% acetic acid and glacial acetic acid respectively. The concentration of the polymer solution was 10 mg/mL. The sludge was mixed for 45 s at 100 rpm with a jar apparatus to ensure sample homogeneity. Polymers were added in different beakers and the mixing continued at 100 rpm, for a further 120 s. After the rapid mix, the sample was gently mixed at 20 rpm for 90 s and specific resistance test was made directly after the final mixing.

The specific resistance is calculated from the Buchner funnel test according to the following equation:

$$R = \frac{2PBA^2}{\mu C} \qquad \text{(a)}$$

where

B = slope of T/V versus V plot

T = time in seconds

V = filtrate volume in cm^3

P = applied pressure in N/cm^2

μ = absolute viscosity in N-secs/cm^2

C = weight of solids deposited per unit volume of filtrate in g/cm^2 and is given by

$$\frac{1}{\frac{100 - C_i}{C_i} - \frac{100 - C_f}{C_f}} \qquad \text{(b)}$$

C_i = initial moisture content in per cent and

C_f = moisture content of filter cake in per cent.

The coefficient of compressibility 's' with respect to specific resistance and pressure is given by

$$\frac{\gamma_2}{\gamma_1} = \left(\frac{p_2}{p_1}\right)^s \qquad \text{(c)}$$

where

γ_2 = specific resistance at pressure p_1

γ_2 = specific resistance at pressure p_2

s = coefficient of compressibility

Determination of Optimal Polymer Dose

The specific resistances of sludge samples were calculated at different polymer doses. Optimal polymer dose determination was made by plotting the polymer dose against specific resistance and choosing that polymer dose at which minimum resistance occurred. Later the sludge samples were adjusted at three different pH levels (10.0 ± 0.4, 8.0 ± 0.4, 4.0 ± 0.4) and the specific resistance and coefficient of compressibility were calculated and recorded (Figs. 1–6).

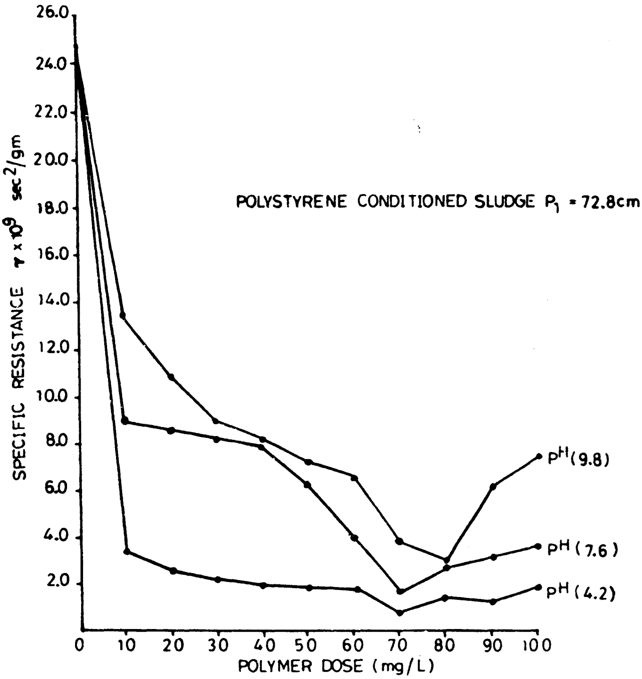

Fig. 1. Effect of polystyrene on the specific resistance of sludge

Conclusions for Polystyrene Polymer

1. At pH 9.8 the optimal polymer dose was 80 mg/L with specific resistance 3.136×10^9 sec^2/g and 1.5779×10^9 sec^2/g at pressures 72.8 cm and 40.1 cm of Hg respectively. The coefficient of compressibility was 1.15 (Figs. 1, 2 and 5).
2. At pH 7.6 the specific resistant at an optical polymer dose of 70 mg/L was 1.5518×10^9 sec^2/g and 0.6773×10^9 sec^2/g at the pressure indicated above (Figs. 1, 2).
3. At pH 4.2 once again the optimal dose was 70 mg/L only, the same as that at pH 7.6 but the specific resistances further decreased to 0.8010×10^9 $sec^2/$ g and 0.4933×10^9 sec^2/g.

Thus the result showed that the optimum pH for effective conditioning might be between 4.2 and 7.6. The specific resistance decreased with increase in the hydrogen ion concentrations.

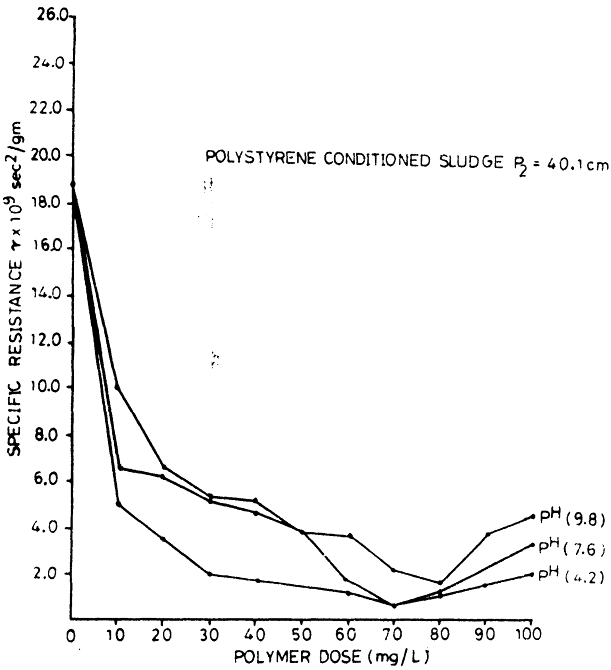

Fig. 2. Effect of polystyrene on the specific resistance of sludge

For Polymethylmethacrylate Polymer

1. At pH 10.4 the optimal polymer dose was 80 mg/L with the specific resistance of 0.201×10^9 sec^2/g and 0.1057×10^9 sec^2/g at pressure 70 cm and 40.2 cm of Hg respectively (Figs. 3 and 4).
2. At pH 8.1, the optimal polymer dose was 70 mg/L. The specific resistance was 0.208×10^9 sec^2/g and 0.1030×10^9 sec^2/gm under the same conditions of the experiment (Figs. 3 and 4).
3. At pH 4.6, the optimal polymer dose decreased to 60 mg/L and the specific resistance was 0.968×10^8 sec^2/g and 0.459×10^8 sec^2/g at the same pressure.

It may be noted that over the pH range 8.0–10.4, the specific resistance practically remains constant whereas under acidic pH conditions a heavy fall in the value occurs.

Coefficient of Compressibility (Figs. 5 and 6)

The data indicated that the value of 's' gradually increases with increase in polymer dose and it reached the maximum value at optimum polymer dose. The values at respective polymer doses were 1.1543, 1.3605 and 1.1039 at pH values 9.8, 7.6 and 4.2 respectively for polystyrene and for polymethylmethacrylate, they were 1.2163, 1.3424 and 1.2977 at pH values of 10.4, 8.1 and 4.6 respectively.

In all the pH ranges it has been found to be greater than 0.7 and its maximum value was found to occur at beyond the optical polymer dose pH conditions.

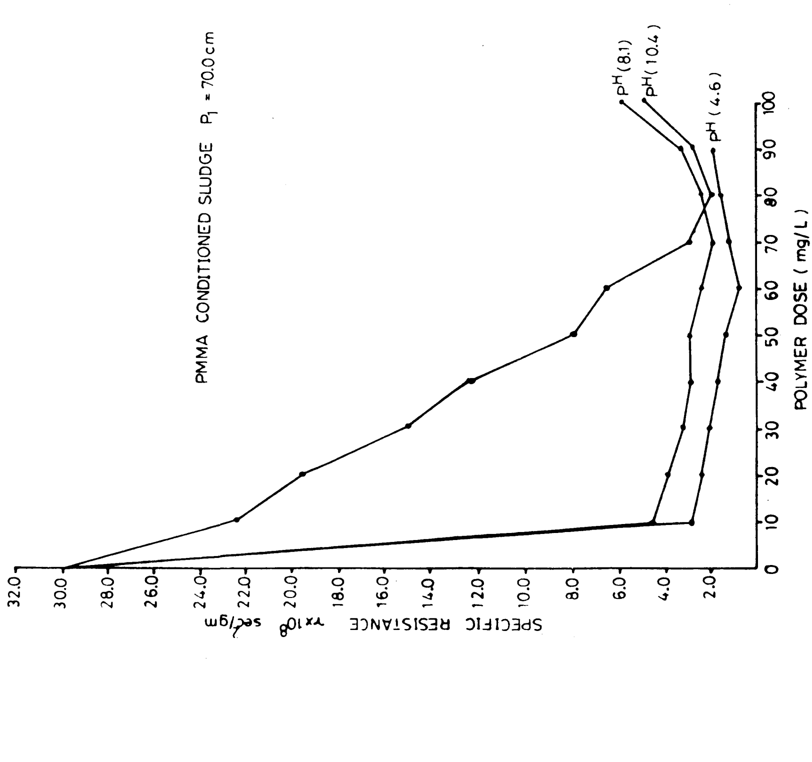

Fig. 3. Effect of polymethacrylatee on the specific resistance of sludge

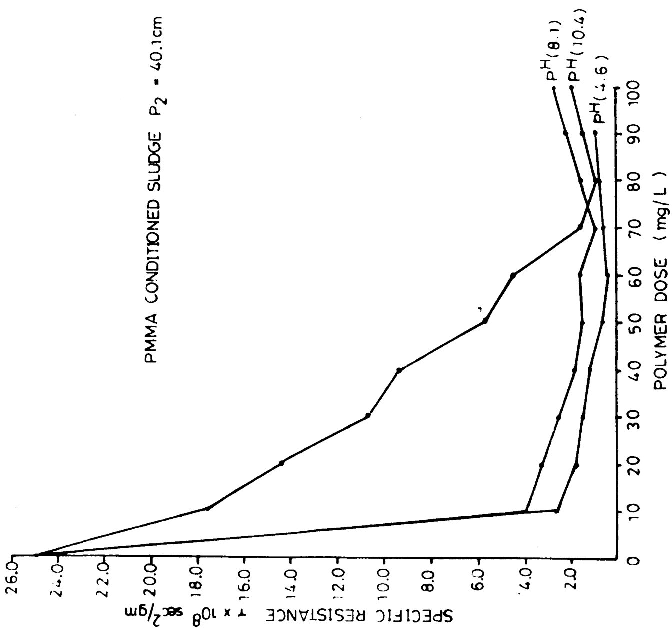

Fig. 4. Effect of polymethacrylatee on the specific resistance ofsludge

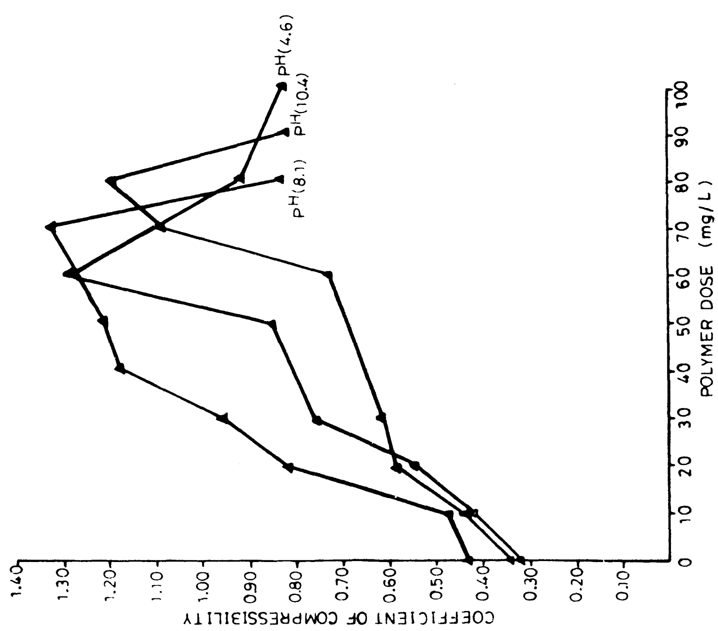

Fig. 6. Effect of polymethacrylatee on the compressibilitye of sludge

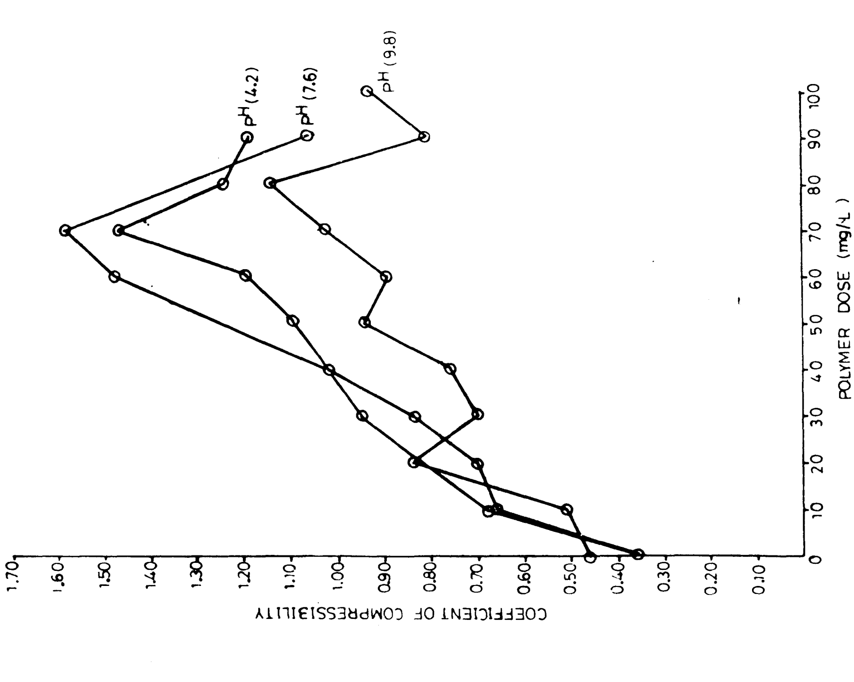

Fig. 5. Effect of polystyrene on the compressibility of sludge

Changes in the pH conditions influenced the coagulation process in the case of polymethylmethacrylate more than polystyrene. It might be due to the fact that polystyrene happens to be completely non-polar at all pH ranges whereas the polymethylmethacrylate might be slightly anionic and ionic and this character might be enhanced at lower pH ranges. It could be stated that polystyrene followed coiling mechanism in the coagulation of solid particles while polymethylmethacrylate followed coiling mechanism coupled with a slight degree of coagulation by neutralization of charges. The specific resistance of polymethylmethacrylate conditioned sludges was found to be lower at all pH ranges.

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