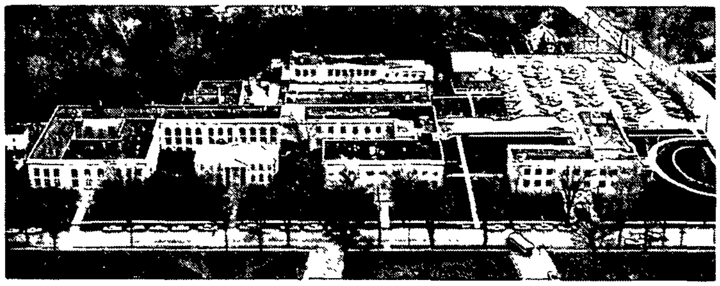

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DEWATERING CHARACTERISTICS OF A SLUDGE DERIVED FROM A COLOR REMOVAL PROCESS

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INTRODUCTION

About one-half the cost of a waste water treatment plant is related to sludge disposal. It is thought that the paper industry will be faced with color removal regulations in the near future. All color removal processes based on multivalent cation precipitation produce sludges. Exacerbating the problem is the fact that there are few sludges more difficult to dewater than those derived from color precipitation processes.

This paper describes work carried out to determine optimum conditions for dewatering sludges derived from lime/magnesium precipitation of color bodies from carbonate pulping effluents.

IPC Technical Paper Series No. 60 deals with work done to determine dosages of lime and magnesium needed to precipitate the color bodies.

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Introduction

There has recently been much interest in substituting a carbonate pulping system for the NSSC process in the manufacture of corrugating medium. Reasons given for this switch include: (a) oversupply of the salt cake by-product made from spent NSSC liquor by fluidized bed incinerators, (b) excessive chemical costs for NSSC pulping chemicals, and (c) concern over the considerable sulfur emission problem associated with the NSSC process (1).

At this same time, regulations regarding removal of color bodies from waste treatment plant effluents are being reviewed. The present paper reports on the dewaterability of the sludge generated by one of the proposed color removal processes, lime/magnesium precipitation. Previous work (2) has outlined the conditions required for color removal from one carbonate pulping process.

Experimental and Results

Generation of sludge

Effluent was obtained from a secondary waste treatment plant treating carbonate pulping effluent. The mill pulps primarily mixed northern hardwoods and produces corrugating medium.

The sludge used to determine the dewatering characteristics was generated by adding the required amount of a magnesium and calcium salt into a standard Phipps-Bird Gang Stirrer. Rapid mixing at 100 rpm was provided for 2 minutes, followed by slow mixing at 50 rpm for 20 minutes, and finally the slurry was allowed to settle for 1 hour before the supernatant was decanted. Optimization of the chemical dosage has been reported (2).

Evaluation of Sludge Characteristics

Rate of settling was determined by timing the descent of the slurry interface in a 1000 ml graduate cylinder. The graduate was equipped with a slow stirring paddle the speed of which was 2 rph. The purpose of the stirrer was to prevent laminar flow near the cylinder wall and to promote sludge agglomeration. The straight line portion of the slurry interface height versus time curve was used to calculate settling velocity.

The specific resistance of sludge to filtration was performed according to standard techniques (3).

Settling Characteristics of the Sludge

This study was intended to reveal some knowledge concerning the factors governing the settling process. The important parameter studied in this test was the settling velocity of the sludge produced at different dosages of calcium, magnesium and combinations of both. All tests were conducted at pH 12, which was shown previously to be optimal for color removal.

Results of these settling tests are presented in Tables 1 and 2.

[Tables 1 and 2 here]

Magnesium forms a gelatinous floc which is difficult to settle and thicken. The settling velocity of magnesium treated effluent sludge is, therefore, much lower than the calcium treated sludge. Moreover, at higher dosages of magnesium, the excess magnesium reacts with NaOH forming a gelatinous mass of $Mg(OH)_2$, which hinders the settling of the floc. This is evident by the rapid decrease in the settling velocity of the magnesium treated effluent sludge as the dosage of magnesium was increased.

Excess calcium, on the other hand, also reacts with NaOH to form $Ca(OH)_2$. But, unlike $Mg(OH)_2$, $Ca(OH)_2$ is a soluble compound and remains in solution. It does not produce any additional sludge. Thus, the sludge interface height practically remains constant for an excess dosage of calcium.

Excess magnesium forms relatively insoluble, gelatinous $Mg(OH)_2$ which increases the sludge volume in the system. This is evidenced by the continuously rising value for magnesium treated effluent sludge volume indicated in Table 2.

The difference between the calcium and magnesium treated sludge settling curve is least at 350 ppm and increases rapidly as the dosage level is increased. This is because at excess chemical dosage levels, more $Mg(OH)_2$ is formed in the system, and consequently gives a wide gap between the settling curve for the calcium and magnesium treated effluent sludge systems. The fact that this gap is least for the dosage of 350 ppm indicates that 350 ppm of either calcium or magnesium is indeed the closest approximation of the optimum dosage required to completely precipitate the chromophoric groups in the effluent.

Settling Characteristics of the Sludge Formed by Using Combined Different Dosage of Calcium and Magnesium

This study was intended to give insight into the influence of magnesium on the settling characteristics of the sludge. All tests were performed at a pH level of 12.0.

Table 3 presents the settling velocities of the sludge as a function of magnesium dosage and at a constant calcium dosage. From these data, it is clearly evident that any addition of magnesium in the system reduces settling velocity of the sludge. Addition of even 10 ppm of magnesium reduces the settling velocity by as much as 27%.

[Table 3 here]

The small variations observed experimentally, shown in Figure 1, can be accounted for by noting that $Mg(OH)_2$ forms gelatinous, unstable flocs which show somewhat unusual behavior under different experimental conditions. A straight line is approximated, indicating that the settling velocity decreases almost linearly as the magnesium dosage is increased. There are no sound theoretical explanations for the experimental anomalies observed in the graph, but the following phenomenon, as explained by Vesiland (3), may be the cause for the fluctuations observed in Figure 1.

[Figure 1 here]

1. It is proposed that there is another settling phase, between the free settling and compression phases, characterized by channel formation. During the compression phase in batch settling, it is often possible to observe small volcanoes forming on the surface. The formation of such volcanoes in batch settling tests result in increased velocities during the volcano phase. Visible channels may also form along the cylinder wall, remain for sometime, and then disappear. This process of channelization is supported by work done on sludge drainage.

2. In addition to channeling, there seems to be another laboratory artifact due to cylinder diameter. This can be called bridging and is again most prominent in small cylinders. At high solids concentrations the sludge tends to bridge or arch across from wall to wall and, as a result, hinders the settling process. This results in slower settling for either small cylinders and high solids concentrations.

Both of these processes were likely to occur in the case of the gelatinous $Mg(OH)_2$ sludge, and can possibly serve as reasonable explanations for the anomalies observed in Figure 1.

Dewatering Characteristics of Sludge: Specific Resistance Determination

The laboratory apparatus used to determine specific resistance is shown in Figure 2. The sludge is loaded into the apparatus and allowed to stand undisturbed for 30 seconds. The vacuum is then applied and the volume of the filtrate collected is recorded as a function of time. The slope of the t/V versus V curve is taken as the specific resistance.

[Figure 2 here]

The conditions used for the dewatering tests can be summarized as follows:

$P = 703$ grams/centimeters^2

$A = 63.6$ centimeters^2

$\mu = 0.11$ poise

Results of several specific resistance tests using lime and/or magnesium are presented in Table 4.

[Table 4 here]

Figure 3 clearly indicates that the specific resistance of sludge to filtration decreases sharply as the dosage of calcium is increased. This is an expected result. Large dosages of calcium have been shown to improve dewatering characteristics of sludges by many workers in the past (4). In fact, at present, some kraft mills are using this "massive lime treatment" method for reducing color and BOD load from mill effluent.

[Figure 3 here]

Figure 4 indicates that addition of magnesium also reduces the specific resistance of the sludge to filtration to a great extent. The curve goes through a minimum value (140×10^8 sec^2/g) and then it begins to rise. At the higher dosages of magnesium, more voluminous $Mg(OH)_2$ forms, which not only hinders the settling rate of the sludge, but also increases the specific resistance of the sludge to the filtration. On the other hand, a high dosage of calcium does not affect the settling velocity of the sludge, but it substantially reduces the specific resistance of the sludge to the filtration. Hence, a large dosage of calcium is preferred over the combination of calcium and magnesium dosage for this reason.

[Figure 4 here]

Effect of Other Chemicals on Dewatering Characteristics of the Sludge

This study was intended to give the relative effect of different chemicals on the dewatering characteristics of the sludge formed by using a stoichiometric dosage of calcium at the optimum coagulation pH.

The result of the calculation of specific resistance to filtration of different sludges formed by using different dosages of various dewatering aid chemicals are presented in Table 5.

[Table 5 here]

The results indicate that none of the usual dewatering aid chemicals improve the dewatering characteristics of the sludge more than that obtained by using 1500 ppm of calcium alone. For all practical purposes, it would be advantageous to use only one chemical rather than using different chemicals in different proportions. Thus, a large dosage (about 1500 ppm) is preferred over any combination of other organic chemicals with a stoichiometric amount of calcium. The use of only one chemical (i.e., only calcium) would give more control and flexibility in normal day to day operation in the mill situation.

Conclusions

1. A large dose of calcium contribute significantly to an increase in size of the particle in the coagulation process. This is beneficial both from the point of view of the settling and dewatering characteristics of the sludge.

2. The sludge settles in the form of a blanket. A clear boundary between supernatant and sludge is observed after about six minutes under experimental conditions.

3. Maximum settling velocity of the sludge was observed by using only 350 ppm (stoichiometric) of calcium as the coagulating agent. A higher dose of calcium was found to decrease the settling velocity of sludge only about 18%.

4. A high dosage of calcium (1500 ppm) does not particularly affect the settling velocity of the sludge, but it does substantially reduce the specific resistance of the sludge to vacuum filtration.

Literature Cited

1. Hanson, J. P., Pulp Paper 52(3):116(March, 1978).
2. Lathia, S. and Joyce, T., in press.
3. Vesilind, P., Treatment and Disposal of Wastewater Sludges, Ann Arbor Science, Ann Arbor, Mich (1974).
4. Taylor, J., "Color Removal from Neutral Sulfite Waste Using Magnesium Coagulation," Ph.D. Dissertation, University of Florida, August, 1974.

Table 1

Observations of the Settling Velocities of the Sludges Formed by Using Various Dosages of Either Calcium or Magnesium Alone

Calcium Dosage (ppm)	Settling Velocity (ft/hr)	Magnesium Dosage (ppm)	Settling Velocity (ft/hr)
200	The particles remain in suspension. No sludge zone formed		
350	4.0	350	2.7
500	3.7	500	1.5
750	3.1	750	1.0
900	3.3	900	0.9
1150	3.4	1150	0.7

Table 2

Percentage Volume Occupied by the Sludge in the Effluent Treated with Various Dosages of Calcium or Magnesium Alone

Settling time = 60 minutes

Calcium Dosage (ppm)	% of Volume Occupied by Sludge	Magnesium Dosage (ppm)	% of Volume Occupied by Sludge
350	13.4	350	18.7
500	17.0	500	25.0
750	17.0	750	38.4
900	17.9	900	59.8
1150	17.0	1150	58.9

Table 3

Observations of the Settling Velocities of the Sludge Formed by Using Combined Different Dosages of Calcium and Magnesium

Calcium Dosage (ppm)	Magnesium Dosage (ppm)	Settling Velocity (ft/hr)
350	0	4.0
350	10	2.9
350	30	2.7
350	50	3.1
350	100	2.3
350	150	2.8
350	200	2.0

Table 4

Observations of Specific Resistance to Filtration of Various Sludges Obtained by Using Different Combinations of Calcium and Magnesium Dosages at pH = 12

Calcium (ppm)	Magnesium (ppm)	Specific Resistance (sec^2/g)	% Solids in Sludge	% Solids in Cake
350	0	7.0×10^8	0.4	23.4
700	0	2.9×10^8	1.6	29.9
1000	0	2.5×10^8	1.9	22.1
1500	0	0.8×10^8	1.3	20.6
2000	0	0.9×10^8	1.2	20.3
350	50	1.5×10^8	0.9	18.9
350	100	1.4×10^8	0.8	20.9
350	150	2.3×10^8	0.9	19.0

Table 5

Observations of Specific Resistance to Filtration of Different Sludges Formed by Using Different Dosages of Various Dewatering Aid Chemicals

Calcium (ppm)	Dewatering Aid	Specific Resistance (sec^2/g)	% Solids in Sludge	% Solids in Cake
350	Alum (25 ppm)	4.6×10^8	1.2	14.2
350	Drewfloc-2270 high anionic polymer (5 ppm)	2.8×10^8	0.6	24.6
350	Ferric chloride (25 ppm)	2.5×10^8	1.2	10.9
350	Sand (20 g/liter)	2.2×10^8	3.2	--
350	Drewfloc-2306 high cationic polymer (5 ppm)	0.9×10^8	0.5	18.4
1500	None	0.8×10^8	1.3	20.6
1000	None	2.5×10^8	1.9	22.1

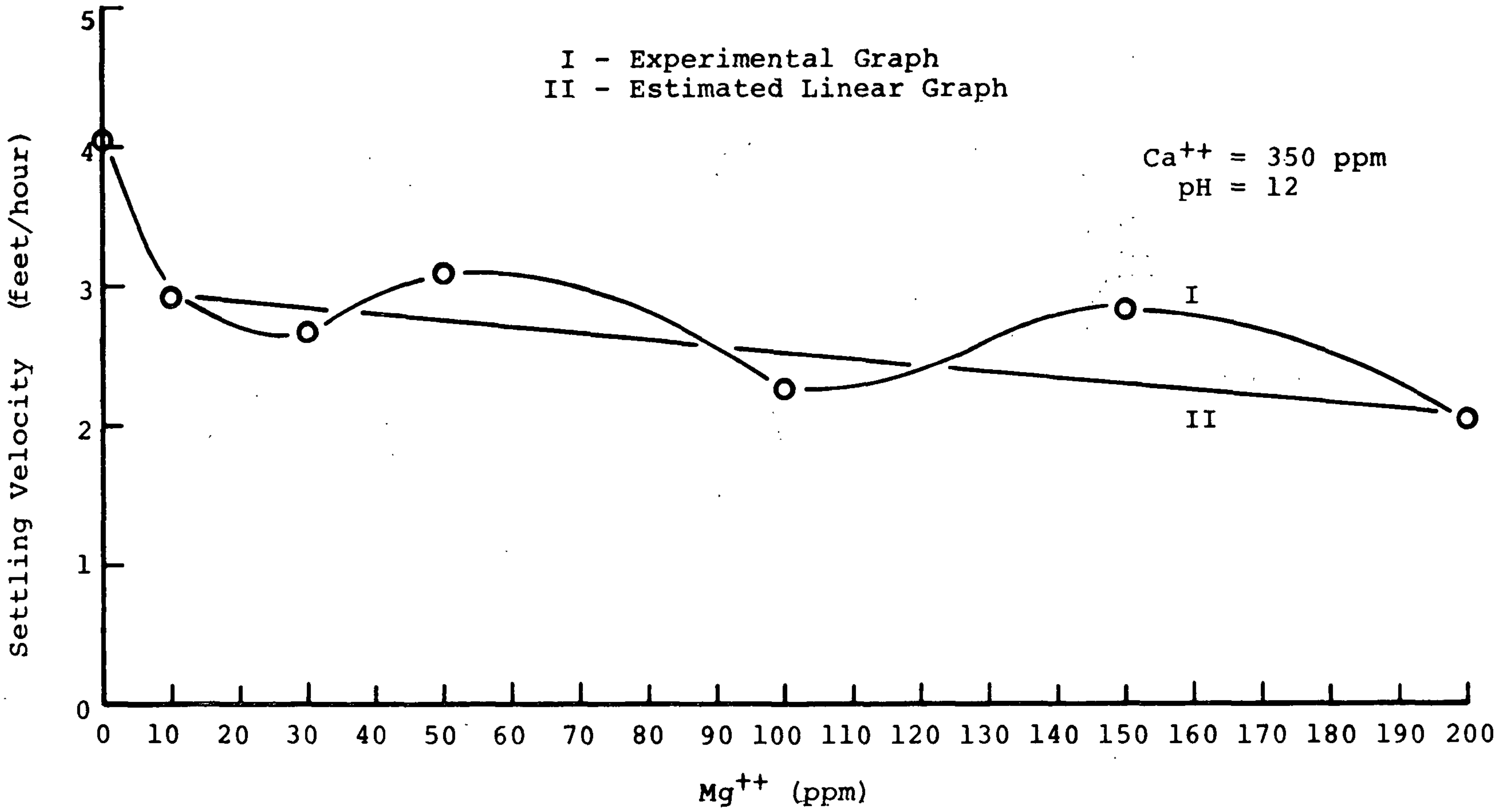

Figure 1. Settling Velocities of the Sludges Obtained by Using Different Dosages of Magnesium to the Effluent, Treated with the Stoichiometric Amount of Calcium at pH = 12

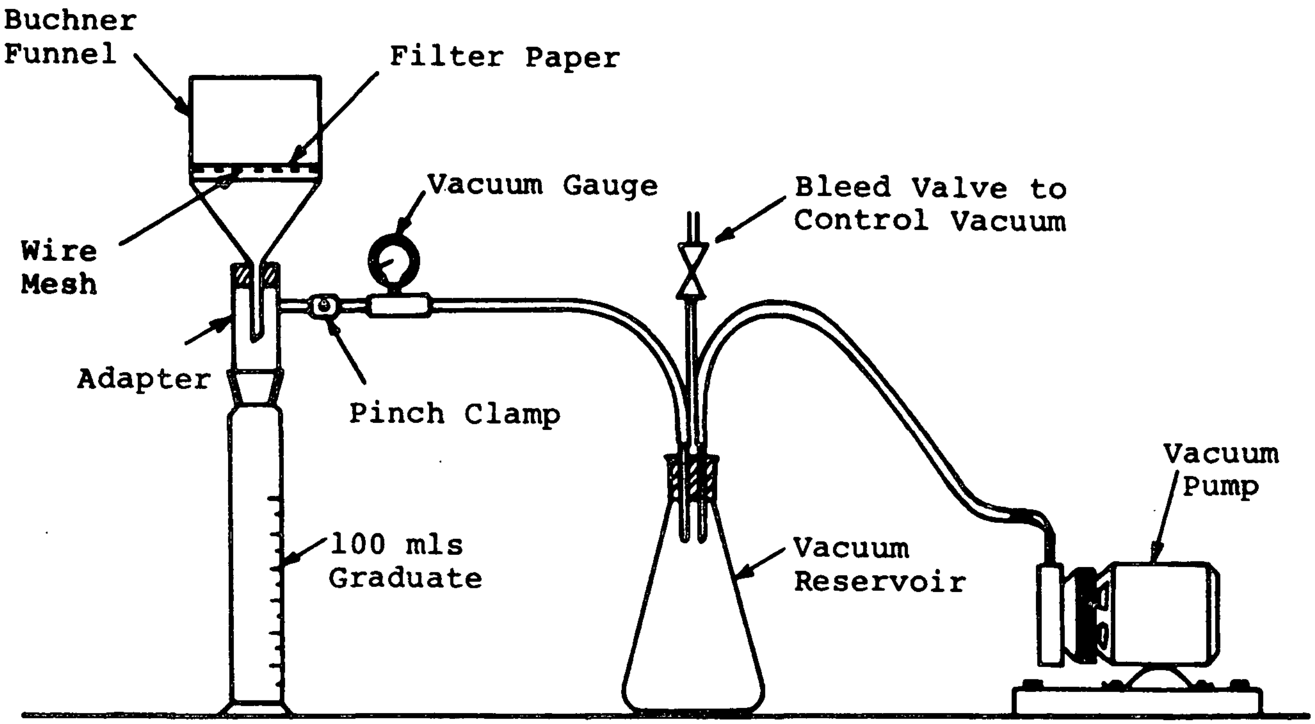

Figure 2. Buchner Funnel Apparatus

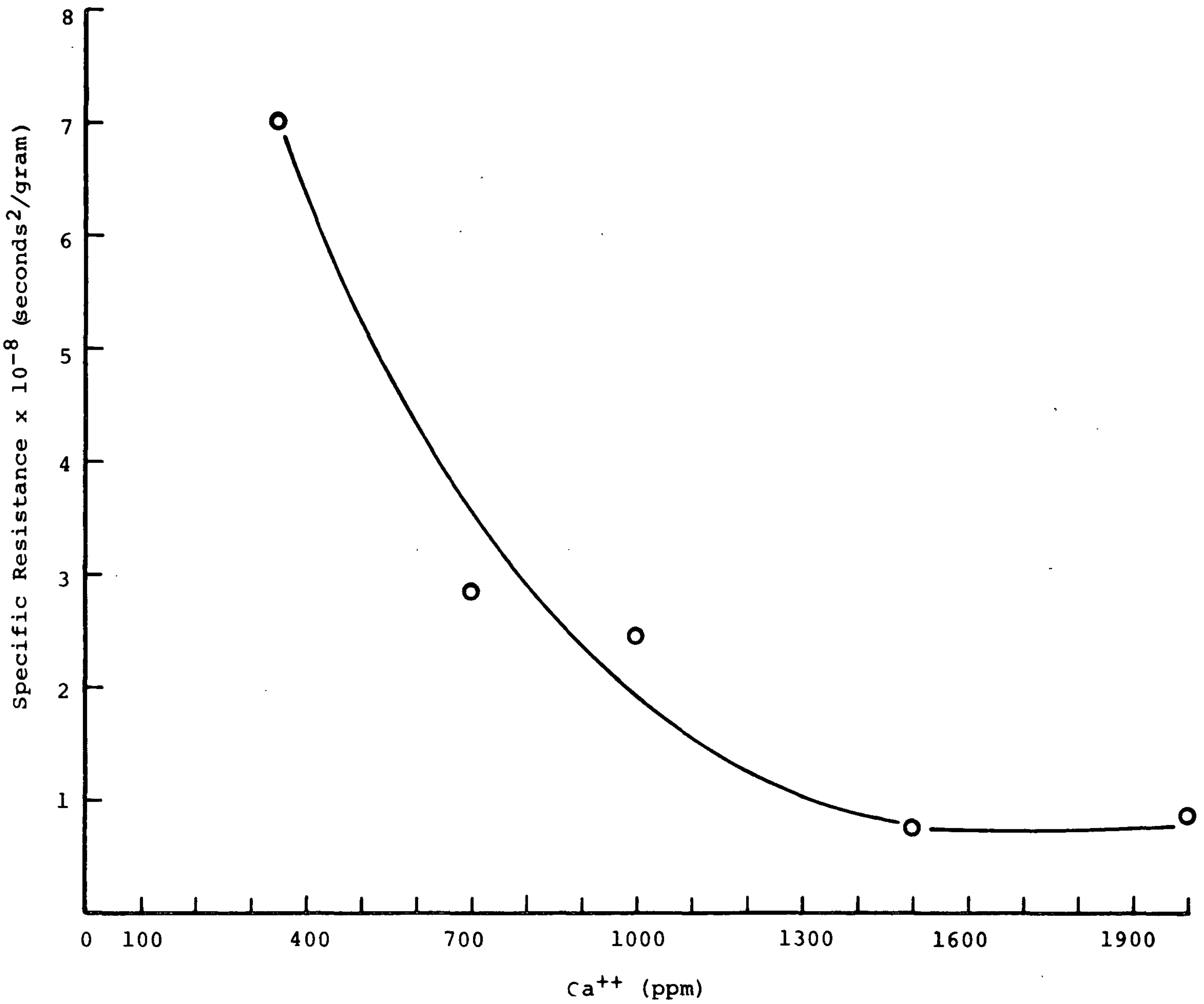

Figure 3. Specific Resistance to Filtration of Various Sludges Obtained by Using Calcium Alone at pH = 12

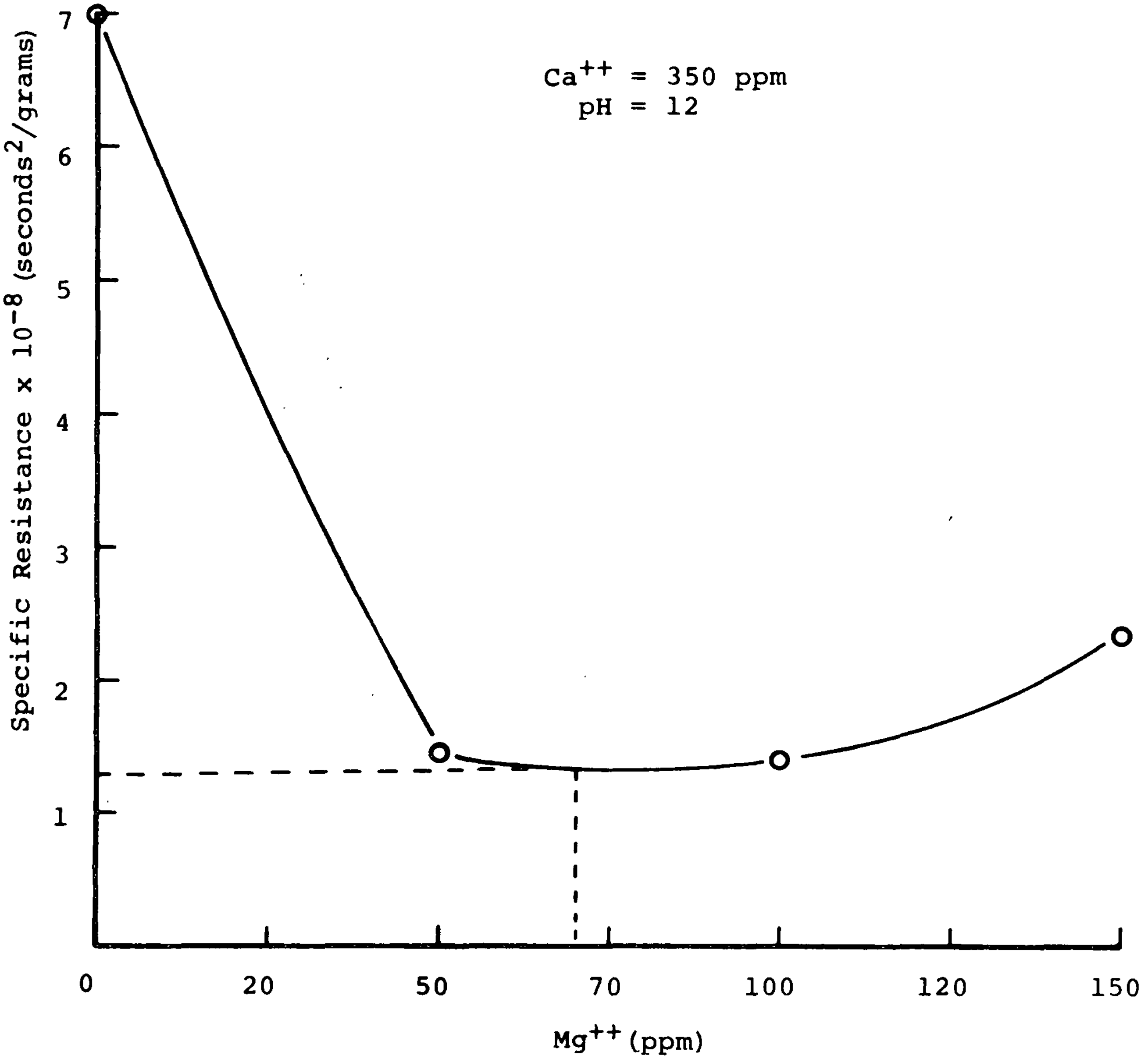

Figure 4. Specific Resistance to Filtration of Sludges Obtained by Using Different Dosages of Magnesium, to the Effluent, Treated with the Stoichiometric Amount of Calcium at pH = 12