PERCOLATION OF SEWAGE THROUGH TANTALUS CINDERS

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ABSTRACT

A pilot study was conducted on the ability of Tantalus cinders to remove organic matter and solids from percolating domestic waste water. Results showed little change in either parameter after passage through 2.5 feet of the cinder. The cinder had a coefficient of permeability of 35,200 gallons/day/ft^2 (1.66 cm/sec) as determined in the laboratory. Under both constant and intermittent flow conditions the infiltration rate of the waste water decreased rapidly to as low as 1.07 ml/min from initial rates of approximately 1300 ml/min.

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INTRODUCTION

Many of the old and new urbanized areas on Oahu are not sewered but are equipped with cesspools for the disposal of domestic waste (Anon., 1960). A laboratory investigation was made of the filtering action of Tantalus cinders on percolating waste water. This material is of interest because it is historically characterized by rapid drainage. The investigation was intended to simulate various conditions occurring within a cesspool composed of Tantalus cinders.

MATERIALS AND METHODS

Soil Columns

Laboratory apparatus consisted of a 2-inch o.d. (1-23/32-inch i.d.) lucite column fitted with a glass wool support and underdrain system. Effluent volumes in the permeability test were collected in graduated cylinders. Effluent samples in the waste water percolation tests were collected in beakers marked at a known volume. Analyses of chemical oxygen demand (COD) and suspended solids were performed in accordance with *Standard Methods* (APHA, 1965).

The material for this study was collected from an open pit along the roadside in the residential area of the Sugar Loaf Spur of Tantalus.

Soil. Less than one percent of Oahu's land area is composed of Tantalus cinders. This material is found mainly in the Tantalus spur in the Koolau range behind Honolulu and encompasses part of a typical watershed area. Some of this land area is in urban or predominantly residential districts, primarily the Makiki, Kaimuki, Punchbowl, and Manoa areas (Nelson, 1963).

The Tantalus soil series is a member of an ashy over cindery, isothermic family of Typic Dystrandepts (Cline, 1955). Typically, these soils have a thick very dark brown A horizon with moderate fine and very fine subangular blocky structure. The B horizon is a very friable, dark reddish brown, very fine sandy loam that rests on unweathered blocks of fine gravel-size cinders at depths of 15 to 36 inches. It is these cinders that were utilized in this percolation study.

The subsoil or cinder is usually covered with 12 to 22 inches of reddish clay material. A further description of the cinder may be found in "Soil Survey, Territory of Hawaii, Series 1939, No. 25" (Cline, 1955).

Permeability

A lucite column was packed with cinders pre-washed to remove fines to prevent the columns from clogging. Water and cinder were added simultaneously to eliminate the possibility of entrapped air in the cinder. As the water and cinders were added, the side of the column was hand-tamped so that the cinder was in a fully-saturated condition. In disturbed samples, fines are generated and since percolation of fluid would carry the fines out of the column, the material was pre-washed by flushing with tap water to remove them. The pre-washing resulted in only a negligible amount of material loss.

The permeability was determined with a constant-head permeameter. The saturated column was filled to a depth of six inches above the cinder surface with distilled water. The effluent was collected in 100-ml graduated cylinders. Time of flow was measured by a stopwatch. Permeability data was calculated at room temperature and converted to 60°F.

The permeability of the column of cinder was found to be 35,200 gallons/day/ft^2 (1.66 cm/sec). Rapid drainage through the column resulted in an occasional air pocket against the side of the column. However, results from these tests were discarded and only data from completely saturated columns were utilized in computing the permeability.

Results of Constant Flow Conditions

The initial phase of tests involved three test runs with waste water from the Pacific Palisades sewage treatment plant percolated through a 2.5-foot column of cinder under constant-flow conditions. The first two runs utilized primary clarifier effluent and the third run was made with raw sewage. These runs were made under saturated conditions with a constant 6-inch depth of sewage maintained over the cinder surface.

The first trial run with primary clarifier effluent revealed that the flow rate decreased from 120 ml/min to 0.33 ml/min during a period of 53 minutes (Figure 1). The greater part of the reduction in flow occurred within the first 5 minutes of the test run.

The COD content of the effluent for the first 25 minutes remained

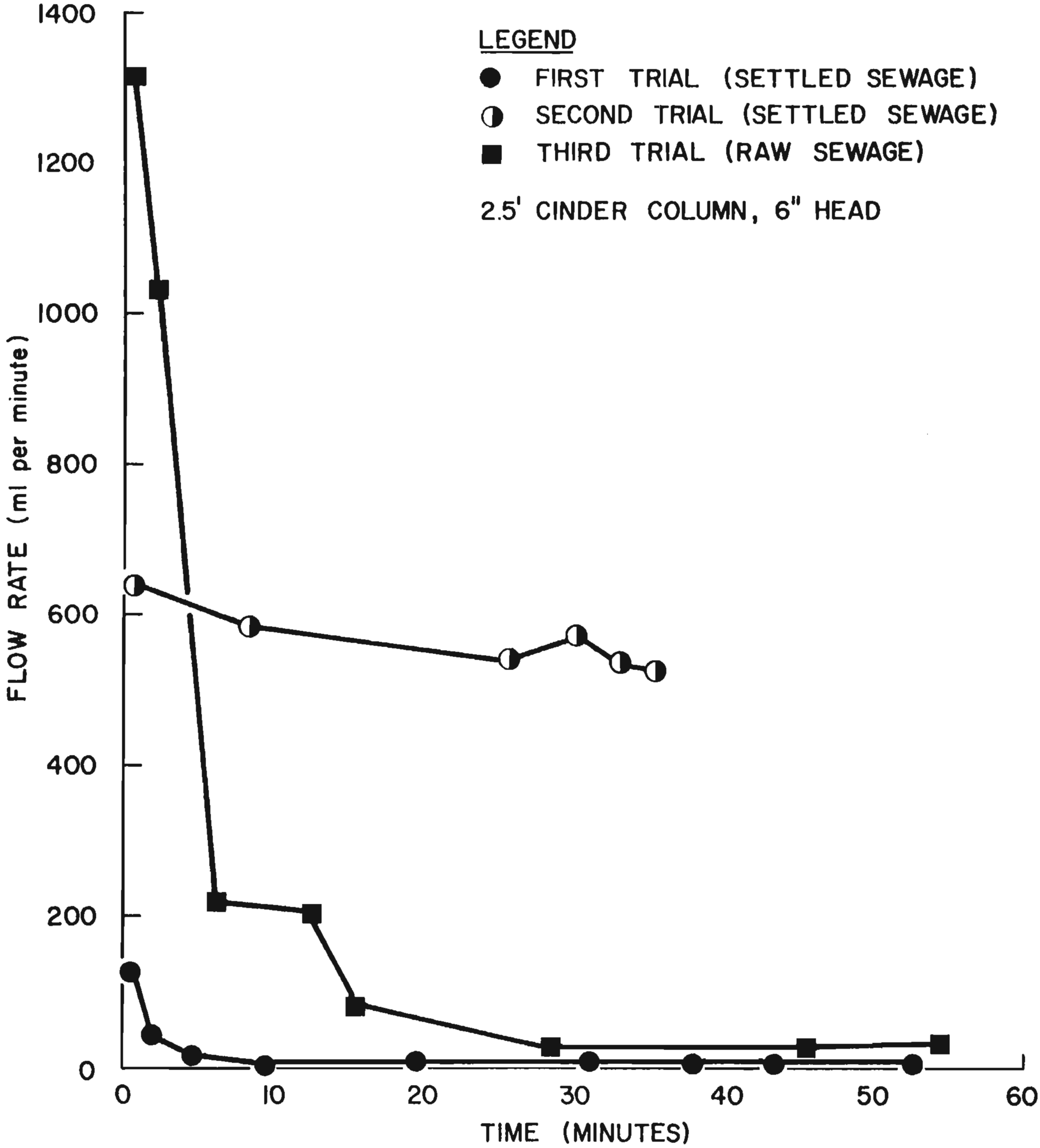

FIGURE I: FLOW RATE THROUGH COLUMN UNDER CONSTANT FLOW.

constant at 200 mg/l (Figure 2) and in the latter phase of the test run, it varied from 200 to 230 mg/l. This may be considered constant in view of the conditions of the experiment.

The large variation in the suspended solids content of the effluent was sufficient to render the suspended solids data inconclusive (Figure 3).

The second trial run with primary clarifier effluent was conducted in an identical manner as the first, but the manner of cleaning the cinders was changed to minimize the possibility of interferences from biological and organic elements. In the initial test run, the material was poured into the column and the fines were flushed out as in the permeability test. In this second trial, the fines were flushed from the material prior to packing the column for permeability and filtration tests.

There was a reduction in flow rate from 628 ml/min to 500 ml/min in a period of 35 minutes (Figure 1). In contrast with the first trial run where a greater reduction in flow rate occurred, the reduction of flow rate was gradual. Further, the flow-rate reduction of the first trial was confined to the early phase of the test run while the second trial run revealed a gradual reduction throughout the test run. Thus, a direct relationship between packing methods and flow patterns was evident in both trials.

The COD content of the effluent remained relatively constant (Figure 2), with random variation in suspended solids concentration (Figure 3) similar to the first trial.

A third trial run was conducted with raw sewage instead of settled sewage from the primary clarifier, more closely simulating actual field conditions. The flow rate (Figure 1) was reduced from 1300 ml/min to 2,4 ml/min within the first half hour. This high initial rate was probably due to a more complete washing and removal of fines before packing the material in the column. Thus, the pore spaces of the cinders were essentially free of fines and allowed a greater initial infiltration rate. From this point of the test run to its termination 43 hours later (this column was maintained for a long duration to ascertain if significant changes in flow rate would occur after the initial sharp reduction), there was a random variation in the flow. The overall pattern of flow during this latter period was a general increase in the direction of the initial rate. The last recorded flow rate was 1200 ml/min. However, there were instances

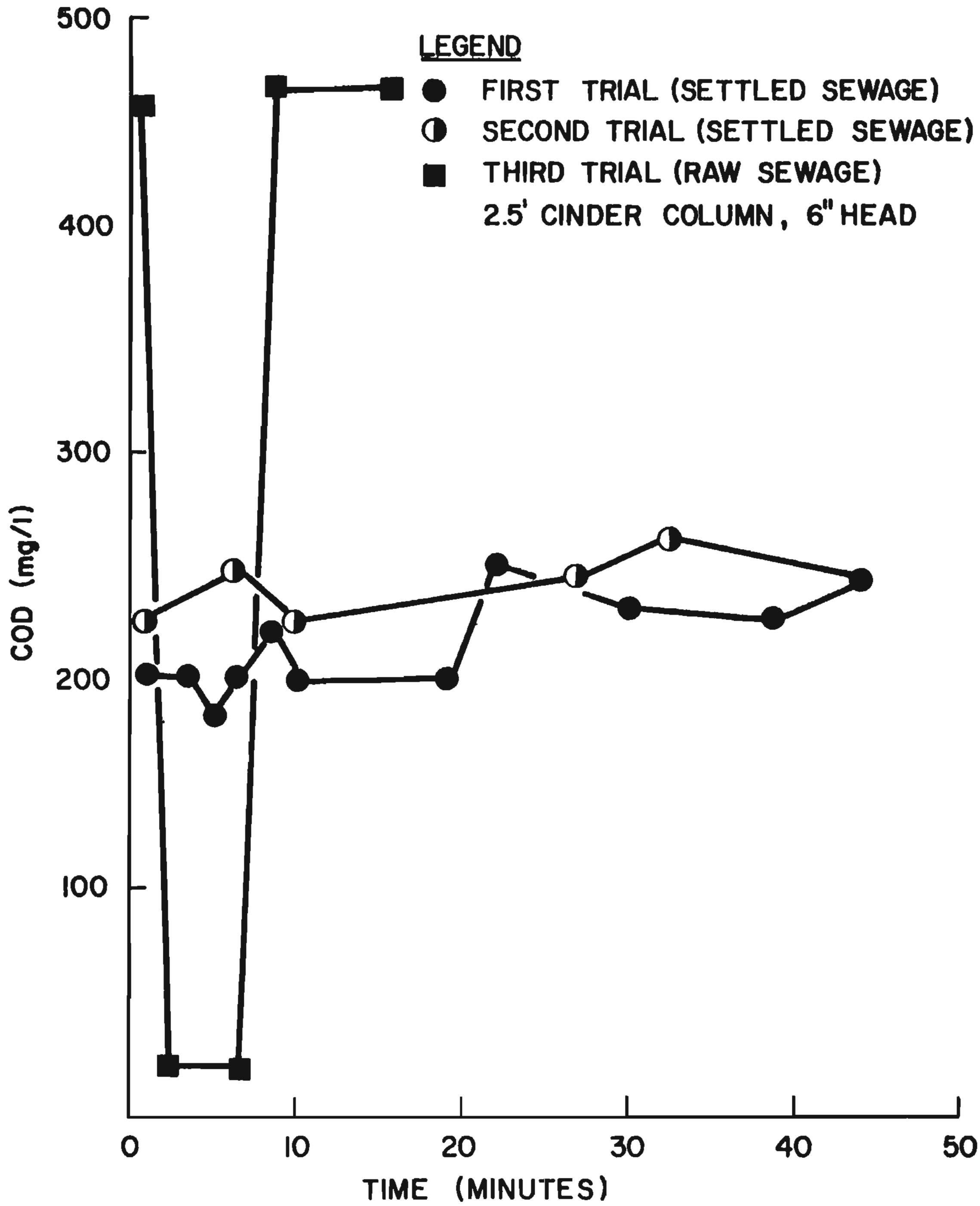

FIGURE 2: EFFLUENT COD UNDER CONSTANT FLOW.

when the flow rate was reduced to as low as 1.07 ml/min. This fluctuation in flow rate may be due to accumulation of organic solids to first hinder flow with subsequent biological degradation to reduce the size of the organic material to allow it to pass through the pore openings in the cinder and thereby increase the flow rate.

There was a large initial reduction in COD from 460 to 24 mg/l (Figure 2). However, a subsequent increase in effluent COD to approximately the feed level was noted.

Although there was an initial reduction of suspended solids, a subsequent constant concentration of suspended solids of approximately 175 mg/l was maintained in the effluent for the duration of the test run (Figure 3).

Results of Intermittent Flooding

The second phase of the experiment involved the effects of intermittent dosing. Ten liters of raw sewage was percolated through a 2.5-foot column of cinder with an initial depth of six inches over the cinder and allowed to drain by gravity. This simulated the flooding or filling of a cesspool. The column was then rested for varying lengths of time. The effluent end of the column was open to the atmosphere during the resting periods allowing for gravity drainage. Prior to refilling the column, it was flushed with sewage for approximately one minute. The effluent end was then clamped shut and the column filled as before with ten liters of sewage.

The flow rate of the initial dosing was reduced from 1370 ml/min to 4.5 ml/min in a period of 100 minutes (Figure 4). The major portion of the reduction occurred within the first 10 minutes.

The COD content (Figure 5) and suspended solids content (Figure 6) of the effluent repeated the random variation obtained under constant flow conditions.

The second dosing of the same column occurred after 2 days of rest. The flow-rate pattern was similar to that of the first dosing. The initial rate of the second dosing was less than the first, 980 ml/min as compared to 1380 ml/min (Figure 4), but the terminal flow rate of the second dosing was 28.6 ml/min as compared to 4.5 ml/min in the case of the first dosing.

Again, the COD content (Figure 5) and the suspended solids content

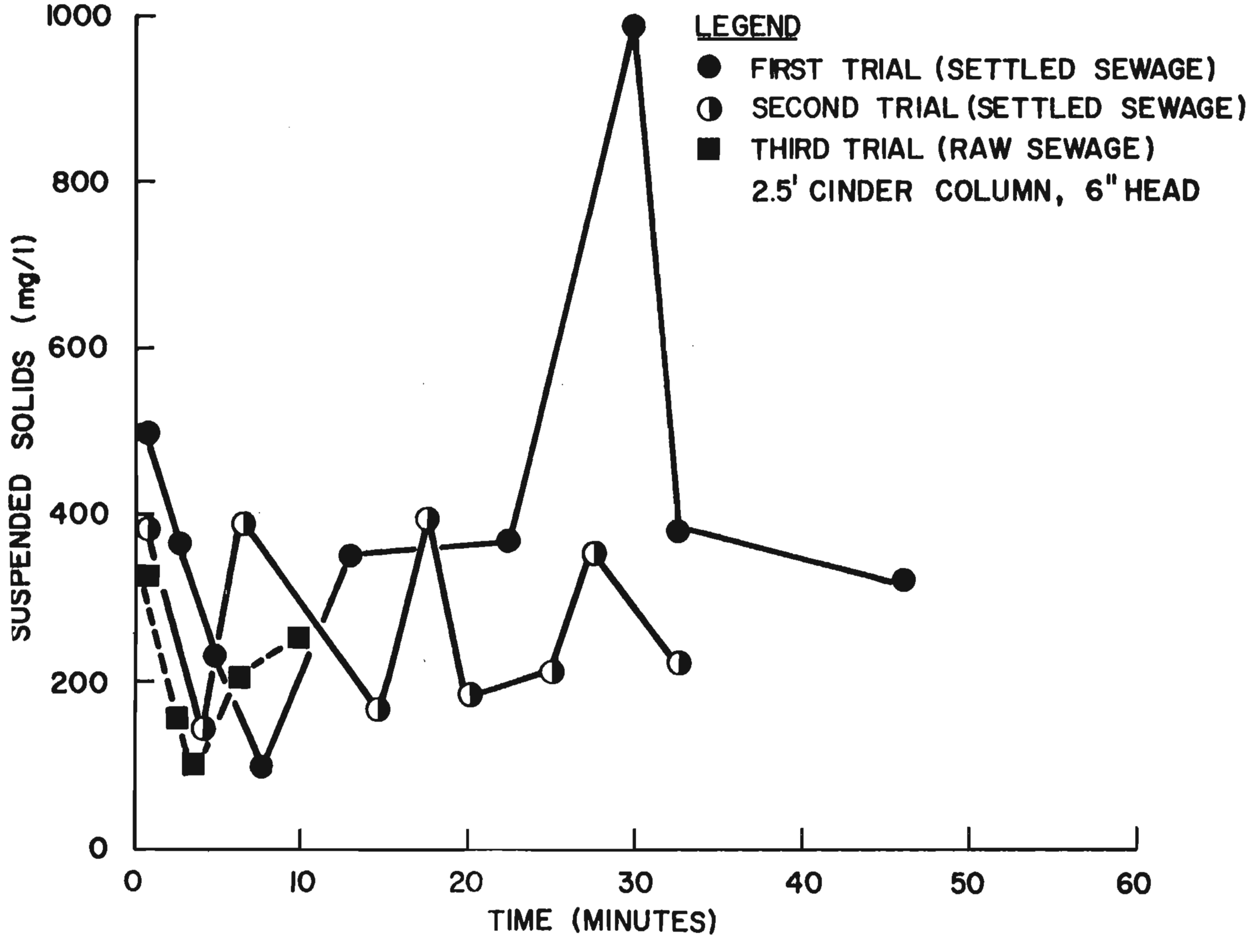

FIGURE 3: EFFLUENT SUSPENDED SOLIDS UNDER CONSTANT FLOW.

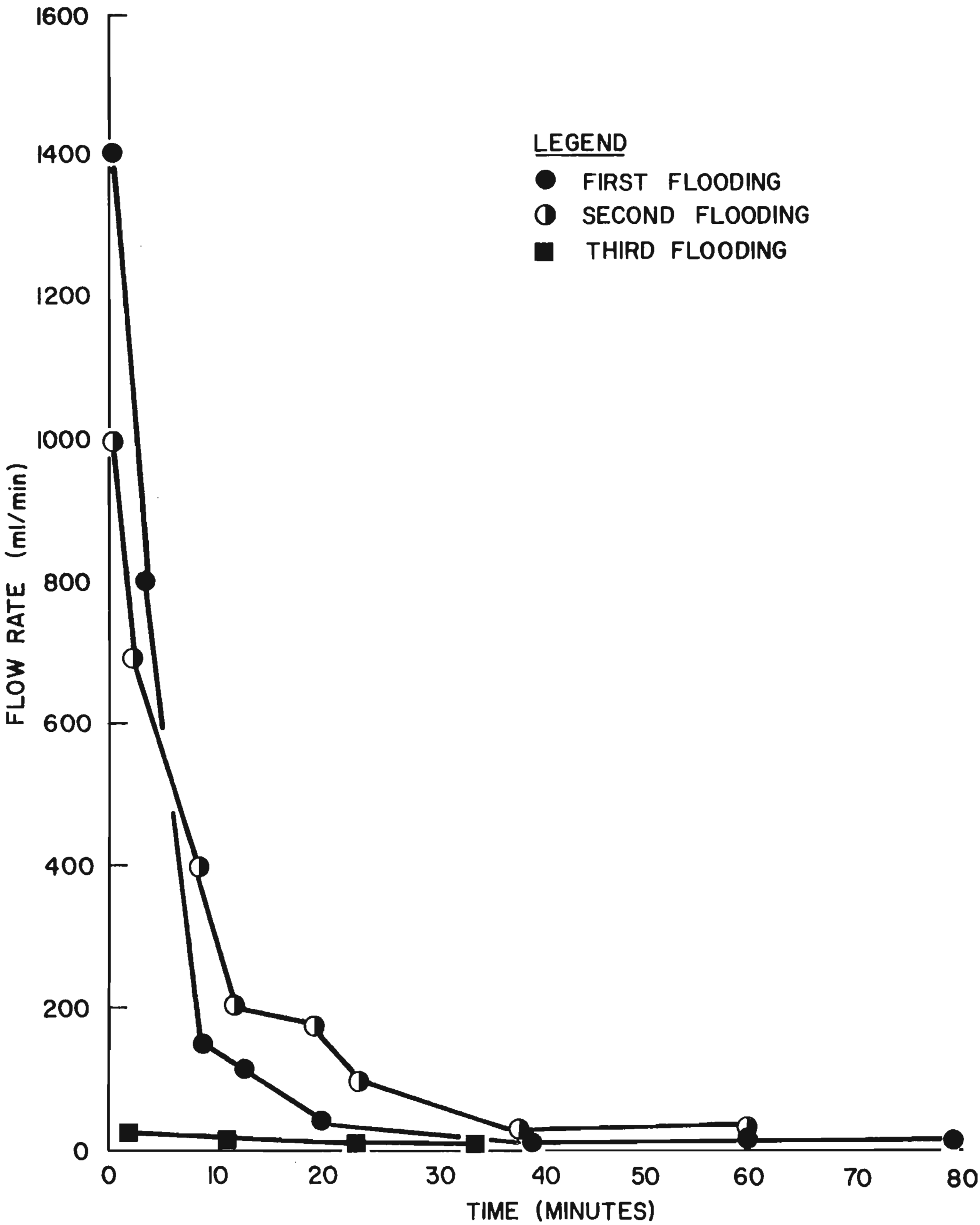

FIGURE 4: FLOW RATES UNDER INTERMITTENT FLOW.

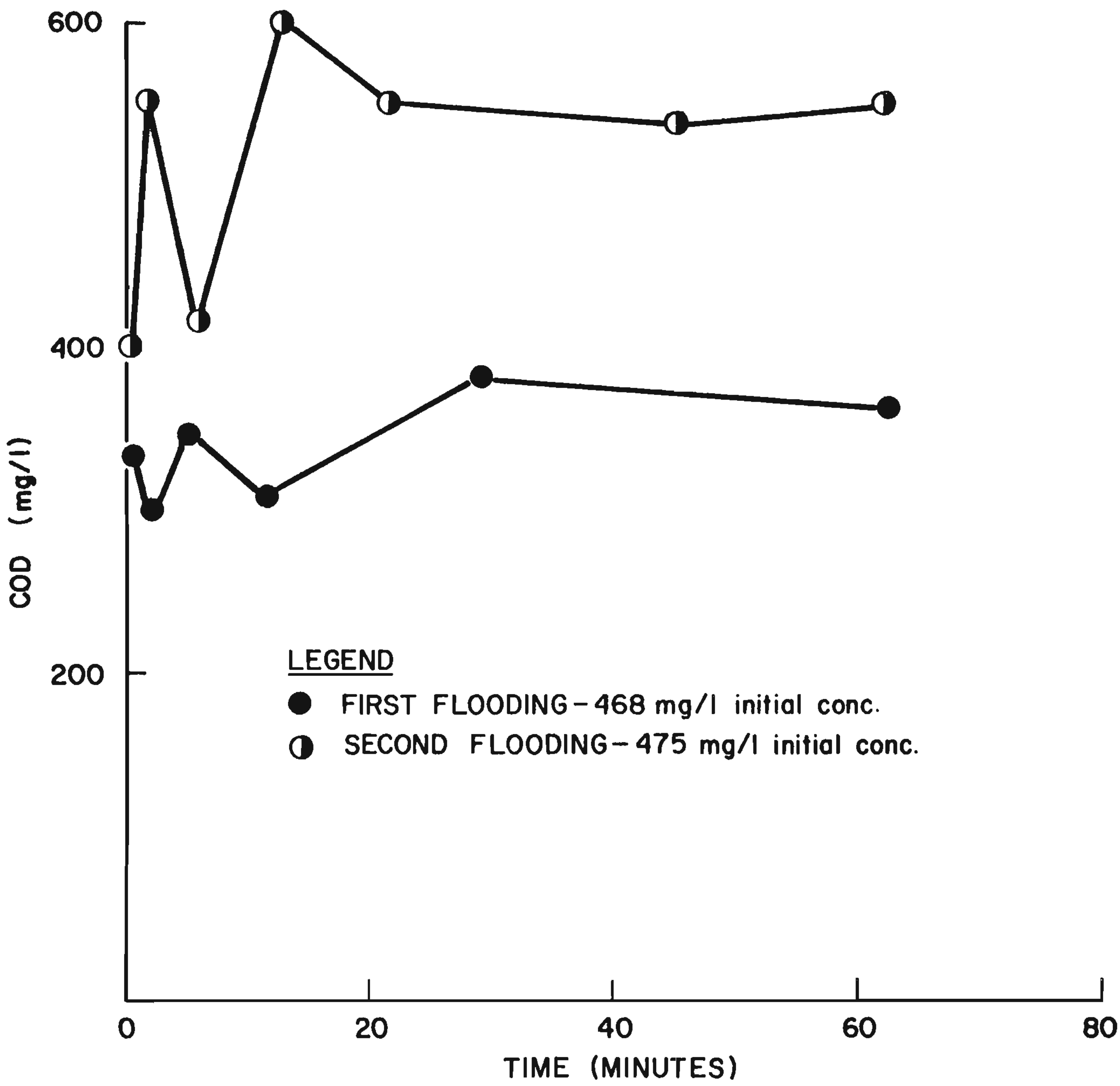

FIGURE 5: EFFLUENT COD UNDER INTERMITTENT FLOW.

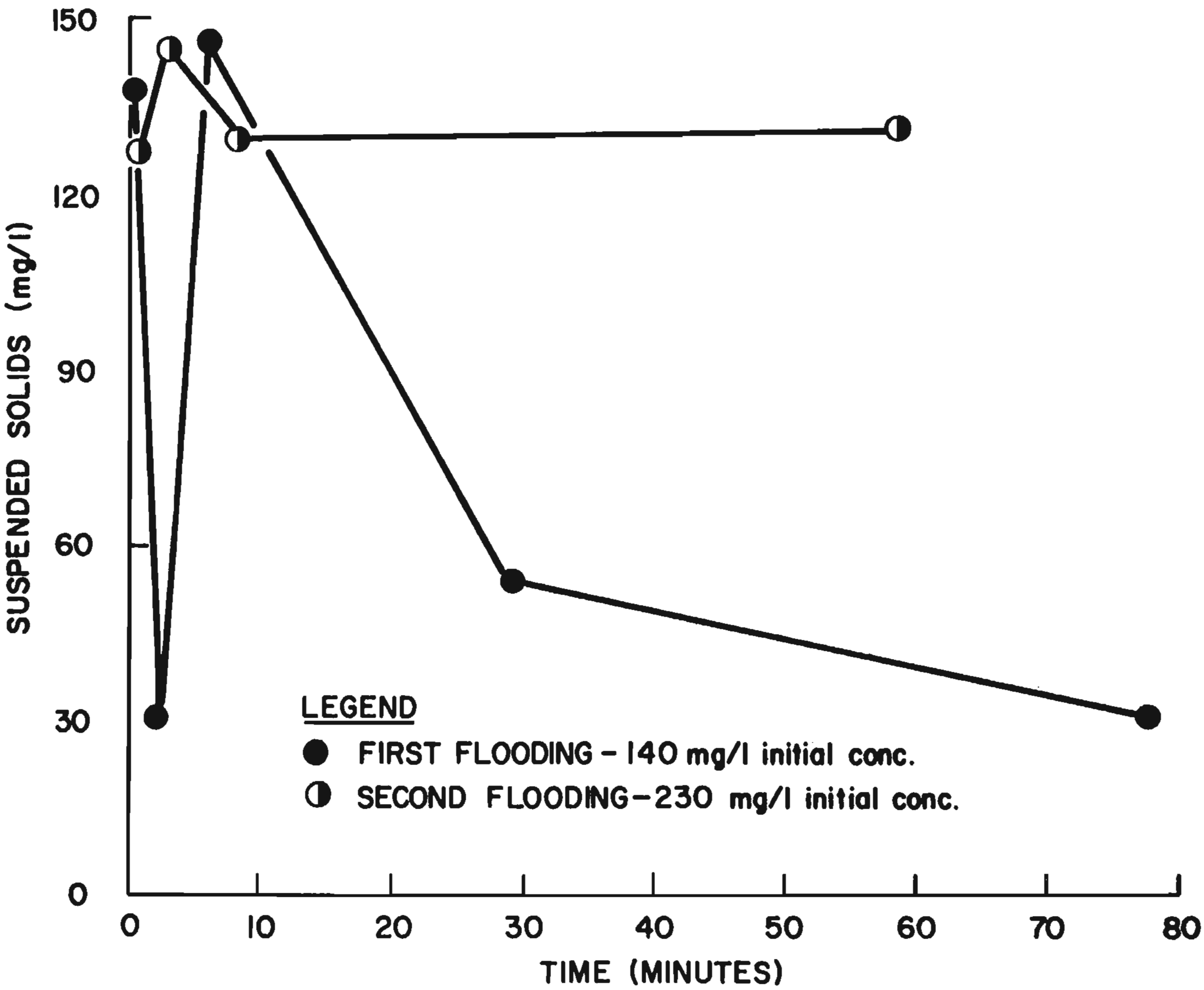

FIGURE 6: EFFLUENT SUSPENDED SOLIDS UNDER INTERMITTENT FLOW.

(Figure 6) revealed a random pattern.

The third dosing was conducted after 5 days of rest. There was no observable flow for the first hour. A mat of solids, the accumulation from previous dosing, had accumulated on the top of the cinder column. This solid material was yellowish-brown in color and had a depth of 1/8 inch. The solids had also penetrated the cinder column about 1 to 1-1/2 inches.

The greatest flow rate was 7.2 ml/min during 40 hours of test (Figure 4). This is considerably less than the initial flow rates of either the first or second dosing. Because of the low flow rates and the consequent small volume of effluent, no COD or suspended solids determinations were made on this third dosing under intermittent flow conditions.

CONCLUSIONS

1. The permeability, which was dependent on the manner of packing, was 35,200 gallons/day/ft^2 (1.66 cm/sec).

2. Most of the infiltration curves revealed a large reduction in flow rate with the majority of the retardation occurring in the initial phases of the experiments.

3. The COD content in the effluent under constant flow conditions remained relatively constant.

4. The suspended solids content in the effluent under constant flow conditions showed no significant reductions in the column.

5. The second dosing of the cinder column under intermittent flow conditions resulted in an initial flow rate of only 75 percent of the initial flow rate of the first dosing.

6. The third dosing under intermittent conditions resulted in an almost negligible amount of percolation for the duration of the test. An accumulation of organic and biological solids formed to effectively prevent flow through the column.

7. There was a large reduction in flow rates under intermittent flow conditions due to accumulation of a layer of solids on the top of the cinders. The solids penetrated the cinder column to a depth of 1 to 1-1/2 inches.

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