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EFFECT OF DEAD ALGAE ON SOIL PERMEABILITY

R. S. Harvey 36871

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SECTION SUPERINTENDENT

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Earth seepage basins are used for the ground disposal of low-level-activity liquid waste from radiochemical separations facilities. Optimum operation of a basin is achieved when the volume of liquid lost through seepage and evaporation is equal to or exceeds the volume of liquid added by waste discharge and rainfall. At the Savannah River Plant, where rainfall approximates the volume lost through evaporation, any reduction in seepage can substantially increase disposal costs by necessitating construction of additional basins.

Since existing basins support heavy growths of unicellular green algae which may be killed by temperature variation or by inadvertent pH changes in waste and then deposited on the basin floor, information on the effects of dead algae on soil permeability was needed. A controlled laboratory study was therefore designed to show the effects of successive algal kills on the permeability of laboratory soil columns.

Procedure Employed

Algae were added to laboratory soil columns and killed by lowering the pH of the water. Following each algal kill, water was passed through both test and control columns until the seepage rates stabilized. Each kill reduced seepage rates through the test columns because dead algae accumulated on the surface of the soil. Maximum pluggage of the test columns reduced initial seepage rates by 76 percent.

Apparatus

Laboratory soil columns were prepared as shown in Fig. 1. The glass columns were 20.3 cm. in length with an inside diameter of 2.9 cm. The bottom of each column was fitted with a two-hole rubber stopper that contained two glass discharge tubes. Sections of rubber tubing, with clamps attached, were placed over the ends of the discharge tubes to allow flow or to maintain liquid in the columns. A layer of glass wool approximately 0.6 cm. thick was placed inside each column, directly above the rubber stopper, to prevent loss of soil through the discharge tubes.

Detailed Technique

The cumulative effects of successive algal kills on the permeability of laboratory soil columns were determined as follows:

COLUMN PREPARATION

1. Sixty grams of finely divided sandy clay soil, representative of the soil existing in basins, was packed in each of eight laboratory soil columns. Four of the columns were used for test and four for control purposes.

2. Distilled water was passed through each column until the soil was thoroughly saturated. A 25-ml. head of water was maintained above the soil to prevent drying.

DETERMINATION OF INITIAL SEEPAGE RATES

1. Four hours after soil saturation three 25-ml. aliquots of distilled water were passed through each column to assure uniform settling of the soil, and to nullify the effect of irregular time intervals between subsequent seepage tests.

2. After the soil settled, a fourth 25-ml. aliquot was added to each column and the time required for it to pass through each was recorded. The times for the test columns and those for the control columns were averaged separately and substituted in the following equation to calculate initial seepage rates.

$$S = \frac{V}{TA}$$

where: S = Seepage rate, $ml/cm^2/min$.

V = Volume passed through column, ml.

T = Time required for volume of water to pass through columns, min.

A = Area of soil surface, cm^2.

REDUCTION OF SEEPAGE RATES RESULTING FROM ALGAL LOAD AND ACID TREATMENT

1. A 10-mg. load of unicellular green algae, similar to the algae existing in the basins, was added to each of four test columns.

2. The algal load was killed by lowering the pH of the water to about 1.5 upon the addition of nitric acid. (Equal volumes of acid were also added to each control column to insure that the test results were independent of the hydrogen ion effect on seepage rates.)

3. Three 25-ml. aliquots of distilled water were then allowed to pass through each column to settle the soil, followed by a fourth 25-ml. aliquot. The time required for the fourth aliquot to pass through each column was recorded. (This comprises the seepage test.)

4. Seepage tests were repeated until the seepage rates for each column became stabilized. At this point full pluggage for each algal load was attained. The last two seepage rates for each algal kill that confirmed full pluggage were averaged and recorded.

5. The reduced seepage rates were subtracted from the initial seepage rates and recorded for both the test and the control columns.

6. The percent reduction of the initial seepage rate in the test columns by each algal load was calculated using the following equation.

$$R = \frac{D - C}{I} X 100$$

where: R = Percent reduction of initial test column rate by algal load.

D = Average test column rate decrease due to algal load and acid treatment.

C = Average control rate decrease due to acid treatment.

I = Initial test column seepage rate.

7. The cumulative effects of successive algal kills on the permeability of the soil columns were obtained by repeating items 1 through 6 until maximum pluggage of the columns resulted from the cumulative algal load. Successive algal kills were made at irregular intervals varying from 9 days to 40 days as shown in the table.

Test Results

The cumulative effects of ten successive algal kills on soil column seepage rates are presented in the following table.

Soil Column Seepage Rates Following Algal Kills

Days	Algal Kill	Cumulative Algal Load, mg/cm^2	Avg. Seepage Rate, $ml/cm^2/min$		Reduction of Initial Test Column Rate	
			Control	Test	$ml/cm^2/min$	%
1	0	0	2.04	2.16	-	-
2	1	1.5	1.41	1.34	0.~~21~~ 19	9
15	2	3.0	1.47	1.23	0.36	17
25	3	4.6	1.45	1.06	0.51	24
34	4	6.1	1.63	0.89	0.86	40
61	5	7.6	1.79	0.46	1.45	67
79	6	9.1	1.81	0.47	1.46	68
97	7	10.6	1.89	0.41	1.60	74
136	8	12.1	1.95	0.43	1.64	76
176	9	13.6	1.81	0.37	1.56	72
205	10	15.2	1.70	0.23	1.60	74

The average percent of the initial seepage rate in the test columns remaining after each algal kill is shown in Fig. 2. The data show that seepage rates of the test columns were reduced an average of 10 percent during each of the first four algal kills. Maximum pluggage of the test columns was achieved when the algal load reached 12 mg/cm^2 following the eighth algal treatment. Initial test column seepage rates were reduced 76 percent due to this loading. Column pluggage was not appreciably affected by two additional algal treatments.

Every effort was made to simulate field conditions in the laboratory so that the test data would be applicable to existing earth basins. Distilled water was used, however, in preference to liquid waste so that test results would show only the effects of the dead algae.

Conclusions

Laboratory data indicate that an algal kill can be expected to partially plug sandy clay soil and reduce the over-all seepage rate of an earth basin. Subsequent algal kills can be expected to have a cumulative effect in reducing the efficiency of a seepage system until maximum pluggage is reached. Although maximum pluggage of the controlled test columns was reached with a loading of 12 mg/cm^2, based on dry weight of algal inoculum, the specific loading which may cause maximum pluggage of an earth basin will also depend on other factors such as: [1] the type of algal growth, [2] the degree of chemical or biological decay of the algae, [3] the type of soil, and [4] the pH of the wastes in the basin.

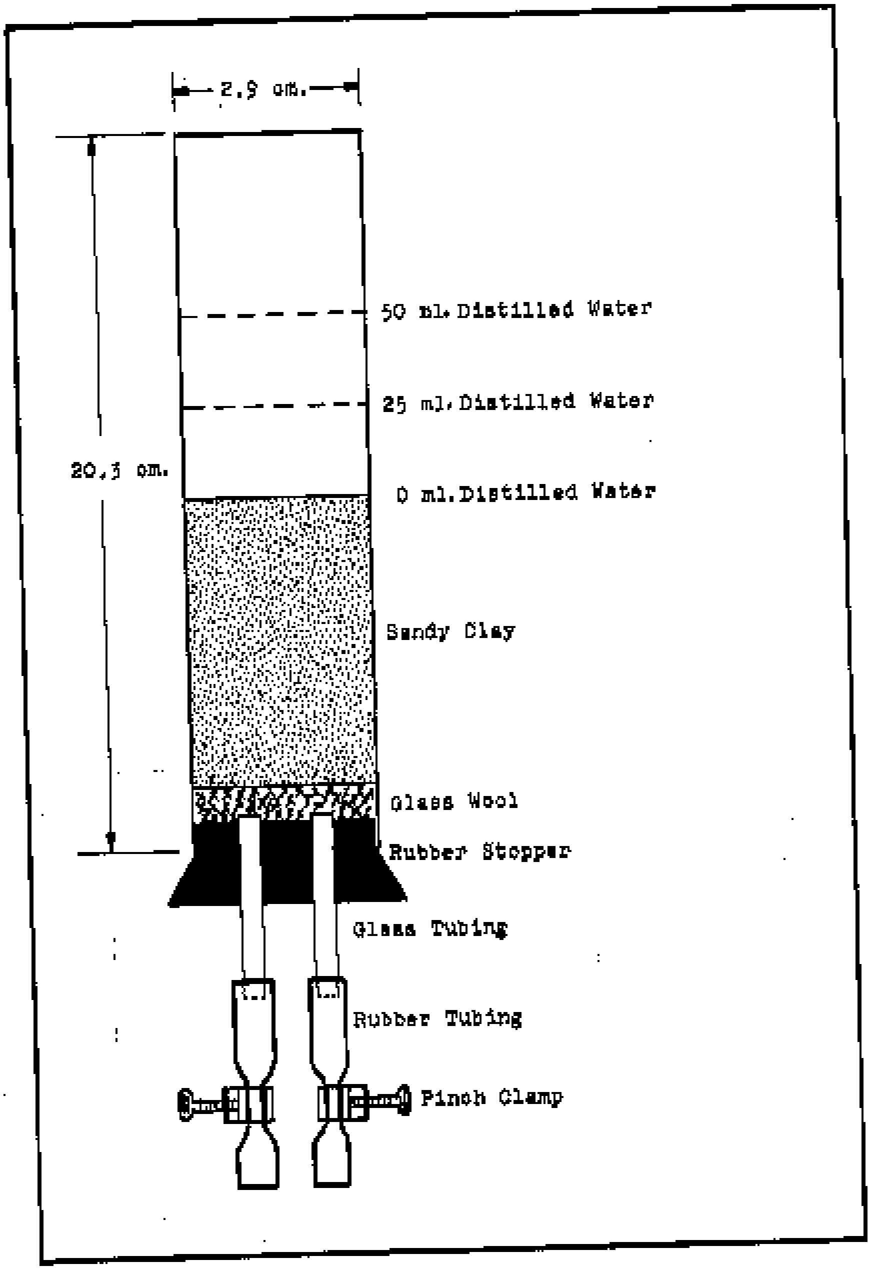

Figure 1. Laboratory Soil Column

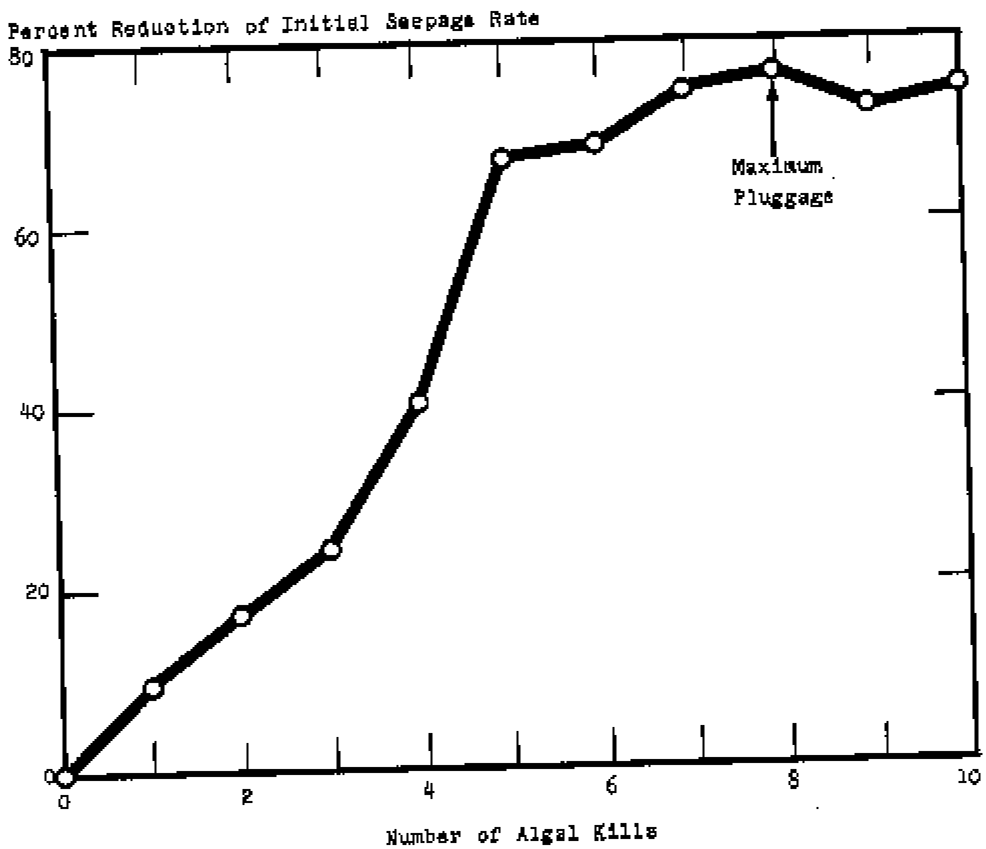

Figure 2. Percent Reduction of Initial Test Column Seepage Rate After Each Algal Kill