BNL 50600

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8-11-77

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DATA REPORT MARSH/POND SYSTEM

MAXWELL M. SMALL

November 1976

MASTER

DEPARTMENT OF APPLIED SCIENCE

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

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UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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Printed in the United States of America

Available from

National Technical Information Service

U.S. Department of Commerce.

5285 Port Royal Road

Springfield, VA 22161

Price: Printed Copy \$4.00; Microfiche \$3.00

April 1977

500 copies

Preface

This project data report has been prepared under the direction of M. Small, the Department of Applied Science, by

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from samples collected and prepared by

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Project operation and maintenance is by the Brookhaven National Laboratory Biology Department Field Operations Group under the direction of F. German. The Engineer of record is J. Hennessy, P.E.

The project is located at Brookhaven National Laboratory, Upton, N.Y.

Funding is provided by the Town of Brookhaven, N.Y., and by the U.S. Energy Research and Development Administration.

SUMMARY

The Marsh/Pond system is one of several experimental facilities that were constructed at Brookhaven National Laboratory in 1973. Since April 1975, these facilities have been used as prototypes for the purpose of developing natural systems to continuously renovate sewage to groundwater rechargeable quality. These systems, as semi-works, continue to be operated in developing modes for this purpose.

The Marsh/Pond system appeared to offer the most promise in meeting the recharge objective after one year's operation in a continuous mode. Because of interest shown in these systems, it was decided to publish the data obtained from this first year of operation of the Marsh/Pond semi-works.

Since this system is still under study, it is believed premature to draw detailed conclusions from these first year data beyond the observation that a Marsh/Pond will convert weak sewage into water which is suitable for recharge through a vegetated sandy loam. This publication of these data is intended to demonstrate that observation.

A supplemental report will be published after the second year of operation of this system. A data report on the first year's operation of the Meadow/Marsh/Pond system is in preparation and also will be supplemented after two years of observation. Specific studies of both systems may be published as separate papers by individual authors in the meantime, as they become appropriate. A Marsh/Pond design which can be recommended for a 250,000 GPD domestic sewage to groundwater recharge system will be discussed in a solicited paper to be presented at the NYWPCA Annual Meeting in N.Y. City in January of 1977. A handbook for the design of this type of ecosystem treatment plant is planned for publication in 1979.

Experimental Design and Operation

The development of these systems is continuing at a Biology Department field site of Brookhaven National Laboratory, Upton, L.I., N.Y. The climate at this location requires special design consideration to assure continuous system operation without storage during the several severe conditions which occur each winter. Annual precipitation averages about 48 inches and there is an average of 31 days each year with more than 1/2 inch of precipitation. Average minimum temperatures are above freezing for the months other than December through March, when the average minimum dips to 23°F. Average daily maximum temperatures are greater than 38°F throughout the year.

System Description

The physical facilities which are used for the development of a Marsh/Pond sewage recharge system under continuous application were not designed for this operating mode and in some respects would not be replicated for this service. Built, planted, and stocked in 1973, all natural system components shown in Fig. 1 and described in detail in reference #2 were fully established communities and all hardware was functioning when the conversion to continuous operation began in April 1975. During the first four months, reliable sewage distribution and application, flow control, sampling techniques, and hardware were developed but useful data-taking did not begin until August of 1975--the beginning of their data reporting period.

Figure 1. Marsh-pond system schematic.

All ponds and the marsh shown in Fig. 1 are sealed off by .020" p.v.c. or p.e. membranes laid directly on the excavated, raked, smoothed, and compacted natural sandy loam on the site.

The marsh was back-filled with 4-6" of muck and was planted to cattails. Other plants subsequently have volunteered including proliferate duckweed and unwanted weeds and grasses. Water depth over the marsh muck did not exceed 2" and is controlled by 5 fixed level overflows to the pond. This water/muck marsh profile and flow arrangement is not optimum for continuous service.

The pond is 5' deep and has a 250,000 gal. capacity which is maintained by a fixed-level overflow to forest recharge. It appears that the pond size is greater than need be for adequate stabilization. The pond is stocked with carp, golden shiners, and fresh water clams. It will support no vegetation other than algae because of the carp.

System Operation

During the data reporting period, aeration and agitation of influent sewage was continuous as was the circulation of influent in the distribution header between the marsh and the hold-up pond: the object, of course, being to obviate any settlement of solids prior to their deposit in the marsh.

Until October, when 2" ball throttle valves were installed at the gutter feed to the marsh and an automatic pump timer was installed to keep the aerated hold-up pond at a constant level, actual hydraulic loading of the marsh proved to be erratic around the design application rate of 50,000 gpd/acre. From October 1975 to April 1976, however, except when the above-ground

recirculating header froze, the 50,000 gpd/acre application rate was maintained continuously to the marsh with little variation. From April 1976 to the end of the reporting period (late August) the marsh application rate was maintained continuously at 100,000 gpd/acre also with little variation. In addition, recirculation of pond water back to the marsh head end was maintained continuously at 5,000 gpd (25,000 gpd/acre) from the beginning of operations in April 1975 until mid-April 1976.

Strong sewage was applied during the early months of system operation and into the beginning of the reporting period in August 1975. The initial high strength was gained by the blending of one part fresh cesspool pumpings with two parts of Brookhaven National Laboratory raw sewage. When the septage, which was delivered by the Town, began to include increasing amounts of digested sludge, to reduce the application of these solids, the blend was reduced to 10 parts of raw sewage to 1 part septage. That 10:1 blend was applied from August 1975 through January 1976, by which time it was clear that the blend was too weak in other contaminants to be representative of raw sewage. The blend was then increased to 5:1 and that mixture has been applied to the end of this reporting period.

An examination of the variation in the influent strengths of the contaminants reported on will show that, on average, this period has been one of testing the Marsh/Pond system performance in treating a weak sewage under increasing hydraulic application rates. Because of hydraulic and strength variations

over this period, data are reported in p.p.m. As of August 1976, it was concluded that a desirable hydraulic limit had been reached at 100,000 gpd/acre and that sufficient information had been gathered on the system's performance in renovating weak raw sewage or the equivalent of secondary or primary treated sewage at that application rate. These are the numbers reported herein.

The system began operating with strong concentrations of raw sewage only at the 100,000 gpd application rate in September 1976 and will be continued in this mode until September 1977. The supplemental Marsh/Pond data report, when issued, will then allow a comparison of this system's performance during a year each of strong and weak applied sewage.

Sampling and Analysis

Data reported are for the Marsh/Pond system as a whole. Fig. 1 shows A as the point at which influent to the marsh is applied and sampled and D as the point at which rechargeable effluent from the pond is discharged and sampled. No data are presented for any other points in the system.

Normal procedure for sampling these points is to set up a composite sampler with a one gallon refrigerated sample holder, both in a protective enclosure, at each of points A and D, at 9 a.m. on a Monday; to collect this 24 hour refrigerated composite on Tuesday and again on Wednesday, Thursday and Friday. Each 24 hour refrigerated sample is divided among several separate four-day frozen composites for delivery each week to the Brookhaven National Laboratory Microbiology and Chemistry Laboratories for N, P and C analyses, to the Suffolk County

Water Authority Laboratory for inorganic chemical analyses and to Lauman Laboratory for solids analyses. In addition, one gal. grab samples are taken at A and D each Friday for immediate delivery to Lauman Laboratory for BOD₅ and COD analyses. At the time of each sample taking, the field technician records temperatures and pH. Grab samples for bacteria analysis are taken by the BNL Virology Laboratory staff at least once weekly. For this report, it has not been possible to make virus analyses, but samples have been taken and frozen for analyses which will be reported on in the supplemental data report. Separate grabs are taken daily at D for determination of any radioactivity present: no reportable concentrations have been found.

In April 1976, larger four-day composites were taken and analyzed for contaminants of interest but which previously had never appeared in significant concentrations. These include trace organics, pesticides, sulfur compounds, lead, mercury, nickel, selenium, silver, arsenic, barium, cadmium, and cyanide. Again, no reportable quantity of any of these contaminants was found at either A or D.

Daily grab samples were taken at E, between the marsh and pond, during this reporting period and have been analyzed by the same laboratories for the same constituents as were the composites from A and D. The measurements at E have been anomalous to an extent that demands further study and they are not included in this report. In August 1976, another automatic composite sampler was obtained and installed at E and it is expected that more consistent results of the performance of the marsh alone can be identified in the next report. For purposes of evaluation therefore, this report presents data on the performance of the Marsh/Pond as a single treatment component in the recharge system.

It is noted also that this report does not attempt to set forth the contributions to renovation made by hold-up recirculation and aeration in the three ponds preceding influent application. The literature is replete with information concerning such conventional pretreatment, and it is postulated that any total treatment system which includes a Marsh/Pond will beneficially include preaeration primarily for odor control and such BOD and NH_3 removal as can be achieved incidental to assuring D.O. in the marsh influent. That this is achieved here is evidenced by the complete absence of scatological odor at any point in the system, by periodic D.O. meter checks and by the continued flourishing of the fish. Regular D.O. level measurements are not taken.

Also, this report does not attempt to delineate the final polishing of the pond effluent by its passage thru the forest floor litter and underlying 12-15 ft. of sand. Again, the literature on land application is sufficient to assure that infiltration of vegetated land by the pond effluent will filter out the coliforms, algae and innocuous solids that sometimes are in the pond discharge. Work here has confirmed similar work reported elsewhere, that this filtration is adequate to obviate disinfection prior to recharge of the groundwater. However, it is emphasized that a Marsh/Pond system is not recommended for recharge except by passage of the pond effluent through or over vegetated soil.

Conclusions

It is not the purpose of this report to explore the Marsh/Pond system performance beyond observing that, with the exception of its content of coliforms, iron, manganese, and turbidity, the effluent from the pond meets established drinking water standards.

It is the purpose of this report to present the principal data from one year's test observation of the Marsh/Pond system which support that observation.

The data are presented in both graphical and tabulated form as concentrations in influent to the marsh and in effluent from the pond for those indicators which are of particular engineering interest. Data of less general interest are tabulated only.

During the report period, for various reasons, data were not taken or reported for the weeks ending October 24, December 26, January 2, January 30 and March 26. Data from all other weeks from July 25, 1975 thru August 27, 1976, are reported.

Data are received from each analytical laboratory in a form suitable for immediate keypunching. Punched card information is first transferred to magnetic tape and loaded in a SYSTEM 2000⁽¹⁾ data base. All processing is by CDC 6600 and 7600 computers. For graphic presentation, the SYSTEM 2000 Report Writer generates a file for plotting by a DISSPLA Graphics⁽²⁾ package and a Cal Comp Plotter.

(1) SYSTEM 2000 is a registered service mark of MRI Systems Corp., Austin, Texas.

(2) DISSPLA is a proprietary software product of Integrated Software Systems Corp., San Diego, Calif.

Exhibits are as follows:

Table 1, summarizes, for the report period, the measured constituent characteristics of the sewage influent to the marsh at point A and references the Figures giving the monthly average concentration plots of these data.

Table 2, summarizes, for the report period, the measured constituent characteristics of the pond effluent at point D and references the Figures which show monthly average concentration plots of these data; it also shows various effluent criteria recommended for recharge to ground surfaces.

Figures 2-13 are plots of monthly average concentrations in inputs to the marsh against outputs from the pond of principal indicators of interest.

Figures 14 and 15 are plots of monthly geometric mean concentrations in inputs to marsh against outputs from the pond of total and fecal coliforms respectively.

Figure 16 is a plot of monthly average temperatures of sewage influent to the marsh against monthly average temperatures of water effluent from the pond.

TABLE 1.

Characteristics of Influent Sewage at A Averages
for 13 Month Study Period 8/75 - 8/76
(in ppm = mg/l except for pH and as noted)

Parameter	Concentration			Ref. Fig. #
	Average	Max.	Min.	
Total Solids	562	5,300	200	2
Total Volatile Solids	335	3,640	83	3
Total Suspended Solids	353	4,300	50	4
Total Volatile Suspended Solids	235	3,050	35	5
Total Dissolved Solids	208	1,000	127	6
Biochemical Oxygen Demand (BOD) ₅	170	2,700	11	7
Chemical Oxygen Demand	495	7,900	33	8
Total Nitrogen (liquid + solid)	25	91	12	9
Total Kjeldahl Nitrogen (liquid + solid)	19.7	88	5	10
Ammonia Nitrogen (liquid)	8.4	18	.5	11
Total (NO ₂ + NO ₃)-N(liquid)	5.5	17	.7	12
Total Phosphorous (liquid + solid)	7.2	27.7	2.5	13
Orthophosphate-P (liquid)	4.8	22	2	--
Total Coliform (#/100ml)	*59600	20,000,000	1300	14
Fecal Coliform (#/100ml)	* 1560	1,000,000	0	15
pH	6.8	8.9	4.8	--
Turbidity (J.U)	43	400	.3	--
Sewage Temperature (°C)	10	22	-4	16
Specific Conduct. (mho)	464	6,600	250	--
MBAS (ABS)	.3	3	<.02	--
Calcium	20	72	12	--
Chloride	35	110	25	--
Chromium	.05	.5	<.01	--
Copper	.7	3.2	.2	--
Fluoride	.5	1	.2	--
Iron	3.6	20	.8	--
Magnesium	4.3	8.5	3.4	--
Manganese	.14	.75	.06	--
Potassium	5	11	2	--
Sodium	26	52	18	--
Zinc	1.3	4	.3	--

*Geom. mean #/100ml.

TABLE 2.

Characteristics of Effluent Water From Pond
Averages for 13 Month Study Period 8/75 - 8/76
(in ppm = mg/l except for pH and as noted)

Parameter	Ref.	Effluent Criteria	Concentration			Ref. Fig. #
			Average	Max.	Min.	
Total Solids			206	300	142	2
Total Volatile Solids			102	142	40	3
Total Suspended Solids	(11)	30	43	100	14	4
Total Volatile Suspended Solids			35	76	11	5
Total Dissolved Solids	(12)	500	163	242	112	6
Biochemical Oxygen Demand (BOD ₅)	(11)	30	19	46	1	7
Chemical Oxygen Demand			58	120	20	8
Total Nitrogen (liquid + solid)	(10)	10	9.5	18	2.5	9
Total Kjeldahl Nitrogen (liquid + solid)			6.8	14	1.7	9&10
Ammonia Nitrogen (liquid)			3.5	11.5	.05	11
Total (NO ₂ + NO ₃)-N(liquid)	(12)	10	2.6	6.7	.4	12
Total Phosphorous (liquid + solid)			2.1	4	.4	13
Orthophosphate-P (liquid)			1.3	3	.2	13
Total Coliform (#/100ml)	(12)	4	*2000	234,000	40	14
Fecal Coliform (#/100ml)	(11)	200	* 50	10,600	0.00	15
pH			7.4	9.1	6.2	--
Turbidity (J.U)	(12)	5	8.5	74	.7	--
Temperature (°C)			11	24	-6.	16
Specific Conduct. (mho)			262	340	151	
MBAS (ABS)	(12)	.5	.24	1.4	<.02	
Calcium	(10)	Sat.	14	26	8.8	
Chloride	(12)	250	30	46	15	
Chromium	(12)	.05	.01	.03	<.01	
Copper	(12)	1.0	.03	.14	<.01	
Fluoride	(12)	.6	.4	.6	.2	
Iron	(12)	.3	1.2	5.5	.3	
Magnesium			3.6	6.3	2.1	
Manganese	(12)	.05	.1	.3	.04	
Potassium			4	9	.5	
Sodium	(10)	20	25	52	15	
Zinc	(12)	5	.2	.6	.03	

*Geom. mean #/100ml.

Figure 2. Total solids.

Figure 3. Total volatile solids.

Figure 4. Total suspended solids.

Figure 5. Total volatile suspended solids.

Figure 6. Total dissolved solids.

Figure 7. Biochemical oxygen demand.

Figure 8. Chemical oxygen demand.

Figure 9. Nitrogen

Figure 10. Kjeldahl nitrogen

Figure 11. Ammonia nitrogen.

Figure 12. Total (nitrate + nitrite) nitrogen.

Figure 13. Phosphorus

Figure 14. Total coliform.

Figure 15. Fecal coliform.

Figure 16. Sewage and water temperatures.

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