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DATA REPORT MEADOW/MARSH/POND SYSTEM

MAXWELL SMALL AND CHRISTOPHER WURM

April 1977

DEPARTMENT OF APPLIED SCIENCE

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Data Report
Meadow/Marsh/Pond System

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Abstract

The Meadow/Marsh/Pond is one of two natural sewage-treatment systems constructed at Brookhaven National Laboratory. This and a Marsh/Pond system have been in various modes of continuous operation since 1973 and will continue in the future.

Both systems are unique in removing nutrients and contaminants from sewage without the use of conventional hardware or the generation of sludge for separate disposal. They are economical to build and operate. They are attractive systems, free of disease vectors, aerosols and objectionable odors. When sufficient land is available, the Meadow/Marsh/Pond appears superior for renovating blends of septage and weak sewage to groundwater recharge quality.

Because of the interest shown in these systems, it was decided to publish data from one year's operation of each. Marsh/Pond data are available as BNL Report #50600, November 1976. The following report summarizes 13 months operating data, August 1975-August 1976, from the Meadow/Marsh/Pond system. Since this system is still in operation and a second data report will be published after 21 months' operation, the only conclusion now offered is the observation that this system will produce potable water from raw sewage following recharge of its pond effluent through a vegetated sandy soil.

Site of the Work

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 with an average of 31 days each year exceeding 1/2 inch precipitation. Average minimum temperatures are above freezing for all months except 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

Built, planted and stocked in 1973, all natural-system components shown in Figure 1 (marshes, meadows and ponds as detailed in BNL Report #50420) are closed systems. They are sealed off by .020" p.v.c. or c.p.e. membranes laid directly on the excavated, raked, smoothed, and compacted natural sandy loam on the site. Each meadow is sloped at 3% from the gutter-feed application at the top to the collection sump at the bottom. Meadow effluent is pumped from the sumps to discharge into both marshes which merge with either side of the polishing pond.

The meadows were back-filled with 6-8" of site sandy loam and then were planted to Reed Canary Grass. This herdsgrass was chosen because it will thrive with its feet wet, is winter-hardy and makes a good hay. Reed has proved remarkably resilient

Figure 1. Meadow/marsh/pond schematic.

and has resisted all volunteer competing grasses and weeds. This grass requires no maintenance except spot reseeding of some bare spots that will appear after protracted overloading with solids. Three harvests a year are certain with a yield of about eight oven-dry tons per acre per year from the two meadows. It is recommended that the meadow slopes be reduced to 2% in future installations, and that the meadows merge directly with the fringe marshes.

Both marshes were back-filled with 4-6" of muck and were planted principally to cattails. Other marsh plants subsequently have volunteered as have upland weeds and grasses. Water depth over the muck averages 2" and is controlled by the fixed-level pond overflow. Neither water nor muck depth is optimum for best operation in continuous service and both would be deepened over a gravel base in future installations.

The 0.2-acre, 250,000-gallon pond is 5' deep and adequately stabilizes the effluent from the meadows and marshes. It is stocked with catfish, fathead minnows and fresh water clams. Proliferate growth of duckweed from the merging marshes must be harvested from the pond weekly during warm months.

When conversion from experimental modes to continuous operation began in April 1975, marshes, meadows and ponds were fully established communities and all hardware was functioning. 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 this data-reporting period. The physical facilities used for the Meadow/Marsh/Pond sewage-recharge system were not intended for continuous application and in some respects would be redesigned for this service.

System Operation

In order to obviate any settlement of solids prior to their deposit on the meadow, aeration and agitation of influent blend was continuous as was the recirculation of influent through the distribution header between the hold-up pond and the meadows.

Use of the meadows was alternated for three or four week periods during the months of August 1975 through October 1975. Sewage was applied to one meadow while the other meadow was shut down and allowed to dry out. During this period, the meadow that was shut down was harvested and some bare spots were reseeded. Until October 1975, when 2" ball throttle valves were installed at gutter-feeds to the meadows and a pump timer was installed to keep the aerated hold-up pond at a constant level, hydraulic loading of the meadows was erratic around the design application rate of 25,000 gpd/acre.

From October 1975 to April 1976, both meadows were operating in tandem at a combined total rate of 25,000 gpd/acre, discharging effluents from both B_1 and B_2 simultaneously into the marsh/pond complex. Except when the above-ground recirculating line froze, this application rate onto both meadows was consistent. After April 1976, the rate was increased to 50,000 gpd/acre. Tandem operation of the two meadows was continued at this rate until the end of the reporting period (August 1976) when the meadows were returned to a three week alternating mode.

The strength of wastewater applied over the meadows varied greatly from the beginning of operations in July 1975 through the end of this reporting period. Initially, a strong

blend was applied: two parts of Brookhaven National Laboratory raw sewage were blended with one part of mixed cesspool pumpings and package-plant digested sludge. This heavy-solids blend was applied to the meadows only until August 1975, when the meadows began to clog.

A weak blend of ten parts Brookhaven National Laboratory raw sewage to one part septage and sludge was used from August 1975 to January 1976. This blend was not sufficiently taxing to the meadows and was increased to a 5:1 strength from January 1976 to the end of the reporting period.

An examination of variation in the influent strengths of contaminants reported on shows that, on average, this period proved to be one of testing the Meadow/Marsh/Pond system performance in treating a weak sewage under increasing hydraulic application rates. Because of both 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 blends of raw sewage mixed with cesspool pumpings and treatment-plant sludge.

Sampling and Analysis

Data reported are for the meadows, marshes and ponds as a total system. Samples are taken of influent to the meadows at point A (Figure 1) and of rechargeable effluent from the pond at point C. No data are presented for any other points in the system.

Normal procedure for sampling these points is to set up in a protective enclosure, a composite sampler with a one-gallon, refrigerated sample-holder, at points A and C. Collection begins on Monday at 9 a.m. and a 24-hour refrigerated composite is removed 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 C each Friday for immediate delivery to Lauman Laboratory for BOD₅ and COD analyses. At the time of each sample taking, the field technician records temperature 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 a supplemental data report. Separate grabs are taken daily at point C for determination of any radioactivity present: no reportable concentrations have been found.

In April 1976, larger four-day composites were made and analyzed for additional possible contaminants which had been monitored from time to time but had never appeared in significant concentrations. These include trace organics, pesticides, sulfur compounds, lead, mercury, nickel, selenium, silver, arsenic, barium, cadmium, and cyanide. No reportable quantity of any of these contaminants was found at either A or C.

Daily composite samples were taken also at the two intermediate stations, B₁ and B₂ at the end of meadows 1 and 2 during this reporting period and have been analyzed by the same laboratories for the same constituents as were the composites from A and C. However, for purposes of this report, the Meadow/Marsh/Pond components are treated as a single system. The effectiveness of the meadows alone in removing contaminants before their effluent is pumped into the marsh/pond complex, is under study and will be reported in detail subsequently. Their value in producing a usable crop when adequate land is available, and their effectiveness as a nutrient sink has been generally established.

Contributions to renovation made by hold-up, recirculation and aeration in the three ponds preceding influent application are not reported here. The literature is replete with information concerning such conventional pretreatment, and it is believed that a total treatment system which includes a Meadow/Marsh/Pond will beneficially include preaeration, primarily for odor control, but also for such BOD and NH₃ removal as is achieved incidental to assuring D.O. in the meadow influent. That this is achieved here is evidenced by the 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.

The final polishing of the pond effluent by its passage thru the forest floor litter and underlying 12-15 ft. of sand is reported in the literature on land application to be sufficient to 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 also is adequate to obviate disinfection prior to recharge of the groundwater. It is emphasized that a Meadow/Marsh/Pond system is not recommended for recharge except by passage of the pond effluent through or over a vegetated soil.

Conclusions

With the exception of total coliform, iron and manganese, the effluent from the pond of the Meadow/Marsh/Pond system meets established drinking water criteria for the contaminants measured. It is the purpose of this report to present the principal data from one year's test observation of the semi-works system which support that observation.

Data are presented in both graphical and tabulated form as concentrations in influent to the meadow and in effluent from the pond for those indicators which are of particular engineering interest. Data of more 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 2000¹ 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 Graphics² package and a Cal Comp Plotter.

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²DISSPLA 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 meadows 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 C and references the Figures which show monthly average concentration plots of these data; it also refers to various water quality criteria.

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

Figures 14 and 15 are plots of monthly geometric mean concentrations in inputs to meadows 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 meadows against monthly average temperatures of water effluent from the pond.

Table 1

Characteristics of Influent Wastewater at A
 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.	5300.	200.	2
Total Volatile Solids	335.	3640.	83.	3
Total Suspended Solids	353.	4300.	50.	4
Total Volatile Suspended Solids	235.	3050.	35.	5
Total Dissolved Solids	208.	1000.	127.	6
Biochemical Oxygen Demand ₅	170.	2700.	11.	7
Chemical Oxygen Demand	495.	7900.	33.	8
Total Nitrogen (liquid + solid)	25.2	91.1	12.5	9
Ammonia Nitrogen (liquid)	8.4	18.	.51	10
Kjeldahl Nitrogen (liquid + solid)	19.7	87.7	5.	9 & 11
Total (NO ₂ + NO ₃)-N (liquid)	5.5	17.3	.68	9 & 12
Total Phosphorous (liquid + solid)	7.2	27.7	2.5	13
Orthophosphate-P (liquid)	4.8	22.4	1.6	13
Total Coliform (#/100 ml)	*59606.	2 x 10 ⁷	12.5	14
Fecal Coliform (#/100 ml)	* 1557.	1 x 10 ⁶	20	15
pH	6.8	8.9	4.8	--
Turbidity (J.U.)	42.7	400.	.26	--
Water Temperature (°C)	10.33	22.	-4.	16
Specific Conductance	464.	6600.	250.	--
MBAS (ABS)	.3	3.1	< .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	20.1	.8	--
Magnesium	4.3	8.5	3.4	--
Potassium	4.9	11.	2.	--
Sodium	26.4	52.	18.2	--
Zinc	1.3	4.	.3	--

*Geom. mean

Table 2

Characteristics of Effluent Water at C
for 13 Month Study Period 8/75-8/76

(in ppm = mg/l except for pH and as noted)

Parameter	Concentration					Ref. Fig. #
	Ref.	Water Quality Criteria	Average	Max.	Min.	
Total Solids			180.	365.	89.	2
Total Volatile Solids			87.	241.	6.	3
Total Suspended Solids	(11)	30.	39.	104.	13.	4
Total Volatile Suspended Solids			28.	70.	7.	5.
Total Dissolved Solids	(12)	500.	140.	308.	69.	6
Biochemical Oxygen Demand ₅	(11)	30.	13.	62.	2.	7
Chemical Oxygen Demand			48.	120.	16.	8
Total Nitrogen (liquid + solid)	(10)	10.	5.2	15.6	1.3	9
Ammonia Nitrogen (liquid)			1.2	6.8	.04	10
Kjeldahl Nitrogen (liquid + solid)			3.7	12.6	.7	9 & 11
Total (NO ₂ + NO ₃)-N (liquid)	(12)	10.	1.5	3.2	.2	9 % 12
Total Phosphorous (liquid + solid)			1.6	5.3	.3	13
Orthophosphate-P (liquid)			1.1	4.6	.1	13
Total Coliform (#/100 ml)	(12)	4.	*2250.	127000.	40.	14
Fecal Coliform (#/100 ml)	(11)	200.	* 30.	4500.	0.	15
pH			6.9	9.2	6.1	--
Turbidity (J.U.)	(12)	5.	4.8	71.	.6	--
Water Temperatures (°C)			10.6	24.	-2.	16
Specific Conductance (mhos)			224.	315.	165.	--
MBAS (ABS)	(12)	.5	.3	2.9	< .02	--
Calcium	(10)	Sat.	14.	47.	9.	--
Chloride	(12)	250.	29.	85.	17.	--
Chromium	(12)	.05	.02	.3	< .01	--
Copper	(12)	1.0	.04	.2	< .01	--
Fluoride	(12)	.6	.3	.5	.2	--
Iron	(12)	.3	1.5	3.9	.3	--
Magnesium			3.3	4.4	2.3	--
Manganese	(12)	.05	.1	.5	.03	--
Potassium			3.1	11.	.9	--
Sodium	(10)	20.	22.8	30.	15.7	--
Zinc	(12)	5.	.2	.7	.06	--

*Geom. mean

Figure 2. Total solids.

Figure 3. Total volatile solids.

Figure 6. Total dissolved solids.

Figure 7. Biochemical oxygen demand.

Figure 8. Chemical oxygen demand.

Figure 9. Total nitrogen.

Figure 10. Ammonia nitrogen.

Figure 11. Kjeldahl nitrogen.

Figure 12. Total (nitrate + nitrite) nitrogen.

Figure 13. Total phosphorus.

Figure 14. Total coliform.

Figure 15. Fecal coliform.

Figure 16. Influent and effluent temperatures.

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