ENVIRONMENTAL AND ECONOMIC ASPECTS OF LAND APPLICATION OF MUNICIPAL SEWAGE EFFLUENTS

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Irrigation with municipal sewage effluent has been acclaimed as a sewage treatment system that will help eliminate water pollution while promoting the growth of agricultural crops. Investigation of the treatment site at Pauls Valley, however, indicates that wastewater irrigation must be properly managed for these benefits to accrue. Without proper management, sewage irrigation merely transfers the real costs of pollution from the users of water to the users of agricultural land.

INTRODUCTION

The opening paragraph of the Federal Water Pollution Control Act Amendments of 1972 states,".. . it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985 . . ." (1). For the municipal governments of Oklahoma to meet this goal, a redesign or expansion of nearly all of the current sewage treatment facilities will be required. The treatment system recommended by the Oklahoma State Department of Health as the most suitable for the majority of Oklahoma's towns is irrigation with municipal sewage effluent. As a result, municipal governments in the state have begun to enlist the help of farmers in the disposal of municipal wastewaters.

For the farmer, irrigation with sewage effluent involves a new set of management problems which are distinct from irrigation with fresh water. The municipal government wants the farm operator to irrigate the year around at application rates that will dispose of all of the effluent. The farmer's demand for irrigation water, on the other hand, will vary considerably over the year and he may need to be conservative in his application of the effluent to avoid a harmful build-up of salts and heavy metals in the soil.

These management problems are apparent in Pauls Valley, Oklahoma where the city government has built a sewage irrigation treatment system in conjunction with the State Department of Health and the Environmental Protection Agency. Three sewage ponds, an irrigation holding pond, and other irrigation facilities were constructed on the farm of Pauls Valley State School for the mentally retarded at the expense of the municipal government. A farm manager is employed by the school to raise beef and dairy cattle on 360 acres of farmland, of which 260 acres are under irrigation. His situation is similar to that of many independent farmers who may be asked in the near future by an Oklahoma town to irrigate with its wastewater. The objective of this study was to determine whether the farm manager at Pauls Valley would be able to maintain maximum yields and still dispose of all of the effluent on 360 acres of land.

METHODS

The best way to determine the feasibility of an irrigation system that will accommodate the goals of both the city of Pauls Valley and the farm manager is to set up a water balance schedule similar to that published in a recent EPA report (2). This schedule provides valuable information on how a wastewater irrigation system must be managed given a set of management objectives. The schedule designed for Pauls Valley assumes that the total holding pond storage capacity for all four ponds is 153 acre feet (50 million gallons) and that 360 acres are under irrigation. Given these constraints, it is further assumed that an irrigation schedule must be organized in a way that allows all the sewage effluent to be applied to the land. In other words will the system meet the 1985 PL 92-500 goal of "no discharge of any pollutants"?

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Proc. Okla. Acad. Sci. 57: 160-162 (1977)

RESULTS

The water balance table set up for Pauls Valley is designed to equate the inflows and outflows from the sewage holding ponds. Data in the first three columns of Table 1 indicate the amount of water added or lost each month from 45.5 surface acres of the four ponds owing to precipitation and evaporation from that surface area. For the year, there is an average net loss of 21.39 million gallons of water from the surface of the four ponds (Table 1).

Data in the next two columns (4 and 5) indicate the average monthly sewage flows for Pauls Valley. These rates are based on engineering data that show that sewage flow varies with the amount of rainfall. Column 6 is the sum of columns 3 and 5 and represents the total water available for irrigation.

The last three columns (7, 8, and 9) show how the water available for irrigation must be managed to prevent a discharge into the river due to an overflow of the ponds. The number of inches of water that the farmer needs to apply each month to 360 acres of land is shown in column 7 and the millions of gallons used per month on the 360 acres to dispose of all the sewage effluent is indicated in column 8. The last column represents the amount of water stored in the ponds at the end of each month in excess of the 18 inches, which is the recommended minimum depth for optimum operation of the aerobic digestion system. The storage capacity of these ponds is equal to fifty million gallons in excess of the minimum depth. As can be seen from column 9, the storage ponds are filled to capacity in May — a high rainfall month — and are at their lowest level at the end of September, which is the end of the irrigation season.

Two important observations can be drawn from this table. First, for the total water available in column 6 to equal the total water used in column 8 at the end of the year, the farm manager has to apply 29.5 inches of water to all 360 acres of land under irrigation. This is probably 5 to 10 inches more than would be applied in a normal year in the Pauls Valley area.

Also, because of the lack of holding pond storage capacity, the farm manager has to spread his water applications over the whole year rather than just over the growing season. As a result, he has to irrigate in January and February when crops can not use the water and he must be more conservative in his July, August, and September applications to make the water last through the end of the growing season.

DISCUSSION

Even though the city of Pauls Valley might have to expand sewage storage capacity and contract other farmers to irrigate with the effluent, there are strong agricultural, environmental, and economic reasons

TABLE 1. *Storage determination, irrigation requirements, and water balance, Pauls Valley Municipal Sewage Project.*

Month	Precip. (MG[a])	Evap. (MG)	Net (MG)	Sewage flow: Daily Ave. (1000 gal.)	Sewage flow: Monthly (MG)	Water Available (MG)	Irrigation schedule: (Acre inches)	Irrigation schedule: (MG used on 360 acres)	Storage (MG)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Oct.	4.09	6.09	−2.00	925	28.68	26.68	2	19.55	7.12
Nov.	2.59	3.83	−1.24	740	22.20	20.96	2	19.55	8.55
Dec.	2.31	2.61	− .30	690	21.39	21.09	2	19.55	10.09
Jan.	2.08	2.09	− .01	675	20.93	20.92	1	9.78	21.07
Feb.	2.69	2.43	.26	752	21.06	21.32	1	9.78	32.56
Mar.	2.95	4.00	−1.05	786	24.34	23.29	2	19.55	36.31
Apr.	2.79	5.39	−2.60	764	22.92	20.32	3	29.33	27.37
May	7.25	6.44	.81	1320	40.92	41.73	2	19.55	49.54
June	5.27	8.34	−3.07	1074	32.22	29.15	4	39.10	39.63
July	3.36	9.73	−6.37	834	25.85	19.48	4	39.10	20.11
Aug.	3.45	10.08	−6.63	846	26.23	19.60	4	39.10	.58
Sept.	4.29	8.52	−4.23	943	28.29	24.06	2.5	24.44	0.0
Total	35.91	57.30	−21.39	--	267.21	288.60[b]	29.5	288.38[b]	

[a] MG is million gallons
[b] These totals are the same except for rounding errors.

for making alterations in the system that would permit the irrigation schedule to be more favorable to the farmer. From an agricultural standpoint, irrigation with sewage effluent is much different from irrigating with fresh water. Apart from the dangers of a build-up of salts and heavy metals mentioned earlier, the farm manager clearly needs a degree of flexibility in his use of irrigation water. At Pauls Valley the sewage effluent has a high sodium absorption ratio which may cause clogging in some of the heavier clay soils in four or five years. The farm manager needs enough flexibility to rest the land that shows a build-up of elements injurious to plant growth.

Environmentally, irrigation with municipal sewage effluent is an excellent method of disposing of such effluent but its effectiveness is diminished as application rates are increased beyond the level of plant usage. At high irrigation rates, plants no longer are able to remove all of the nitrogen and phosphorus from the water and the chances of run-off or groundwater contamination are increased.

There are two economic justifications for the more conservative and flexible irrigation rates. First, if municipal governments wish to apply the maximum amount of sewage to the smallest amount of land, they will probably have to purchase their own land. In some cases this may be the cheapest alternative. However, in water-scarce areas such as Oklahoma, it should be cheaper to contract with a farmer to dispose of the effluent. The cooperation of independent farmers will depend upon irrigation rates favorable to crop production.

The second economic justification is not as obvious as the first. Relatively little is known about the long-run tolerances of soils and plants for high concentrations of harmful elements. Lower irrigation rates certainly may extend the long run productivity of the land but it is impossible to put a dollar value on this productivity. It may be years before we know whether our precautions are justified, but this may prove to be the most significant in the long run.

The water balance table has been used to bring out two fundamentally different orientations in the use of sewage effluent. The municipal government considers sewage a waste to be disposed of as cheaply as possible. The farmer treats sewage as a resource that must be used prudently in a combination with other factors to produce a crop. Irrigation with municipal sewage effluent is a treatment system that should be designed to use sewage for the benefit of both parties.

A problem arises when an engineer is employed by a city to design a wastewater irrigation system that does not take into account the limitations of the soil-plant complex or the needs of the farmer for the use of water. Most of the case studies of irrigation with municipal sewage effluents found in the literature have been set up on public land where agricultural production is only of secondary importance. As the 1985 deadline draws nearer, many communities will find it necessary to turn to private landowners to dispose of their waste water. To obtain the landowner's cooperation, municipal governments will have to make contractual arrangements that will not restrict the landowners' flexibility in the management of their own property.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Lawrence Morrill, Department of Agronomy, Oklahoma State University, and Delbert Schwab, Oklahoma State University Agricultural Engineering Extension Specialist, for their assistance in preparing this manuscript. The authors also appreciate the financial support of the Oklahoma State Department of Health for this project.

REFERENCES

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