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by

Richard E. Thomas
Municipal Technology Branch
U.S. Environmental Protection Agency
Washington, D.C. 20460

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INTRODUCTION

Treatment of wastewater by allowing it to flow as a thin sheet over gently sloping ground is commonly referred to as "spray runoff," "grass filtration" or "overland flow." The term overland flow has been adopted by the United States Environmental Protection Agency (U.S. EPA) and will be used in this discussion. Overland flow is not a new technology for disposal of wastewater. It has been in use for many decades for disposal of industrial wastewaters and municipal wastewater on a limited basis. Conversely, the concept of overland flow as a treatment process is relatively new. Research to understand the removal mechanisms and the control of these mechanisms by design and operation is a rapidly advancing science.

Research on treating domestic wastewaters by overland flow in the United States started about 12 years ago at the EPA research laboratory in Ada, Oklahoma[1]. Many other Federal, State and private sources have contributed to the rapid development of this promising technology during the ensuring decade. Those wishing to delve into the results of these research efforts should look for the proceedings of periodic workshops such as the one held at Dallas, Texas in September 1980[2]. Those who are more interested in current design information should refer to a design manual[3], or to project specific information available on the rapidly increasing number of systems in design, under construction or now operating[4].

Research and limited operational data available to date show overland flow to offer an energy saving and simply operated wastewater management concept with substantial cost saving potential for smaller communities. Overland flow has potential to treat raw sewage without sludge production. It can be used to upgrade existing treatment facilities inculding primary plants, treatment ponds, and even secondary plants. It will achieve good removal of oxygen demand (BOD), suspended solids (SS), and nitrogen without energy input or chemical addition. EPA; like others; recognizes the benefits which can be achieved if the results demonstrated by research can be achieved routinely in actual practice.

In this context, overland flow is an excellent example of the innovative and alternative technology thrust of the Clean Water Act of 1977. The definition of land treatment in the Act, as extended in the EPA operating guidance for the Construction Grants Program, includes overland flow in the category of alternative technology which makes it eligible for the financial incentives of this program.

Our knowledge of overland flow technology is very dynamic. We are at an important transition point as a decade of research results are about to be verified and improved with performance data from operational facilities. Any state of the art summary becomes rapidly dated in such a period of rapid transition. I will highlight sources of past, present and future information with the objective of guiding interested parties to the best source of information for their needs.

RESEARCH

Research on overland flow in the United States started about 25 years ago when a slow-rate land treatment system treating food processing wastewater was modified to become an overland flow system. Other food processors adopted the concept and overland flow became established as a reliable and low cost process serving many food processing facilities in the 1960's. Research staff at the Robert S. Kerr Environmental Research Laboratory of the EPA initiated a decade of research on treatment of municipal wastewater in 1971. Other Federal, State and several university teams have contributed to a substantial body of information on design and performance. Major sources of key research results are identified in Table 1.

A decade of work has contributed a firm understanding of the basic concept. It is well understood that microbial populations on the soil surface play a key role in the treatment process. I prefer to visualize overland flow as a batch reactor. The flat reactor surface is rough and gently sloping to produce variable liquid depth and residence time. Liquid depth may range from one to twenty-five millimeters while residence time may vary by as much as plus or minus 50 percent of the design time of about 30 to 60 minutes. Overland flow is typically operated with feed periods of 6 to 12 hours per day for 5 to 6 consecutive days. The 12 to 18 hour daily rest periods provide time for biooxidation of the more resistent fraction of the settled solids and reareation of the surface reaction sites. The extended rest after 5 to 6 consective days of feed provides sufficient drying to control insect breeding cycles as well as to return the microbial population to the rapid growth stage. It is important to keep the active microbial population lean, mean and hungry to get the most out of them.

Results to date show that the combination of settling, filtration, microbial degradation and interactions with the soil combine to produce better treatment than conventional suspended growth or fixed-film biological treatment processes. The biochemical oxygen demand (BOD) and total suspended solids (TSS) in overland-flow effluent usually average 10 to 20 mg/l with maximum values seldom exceeding 30 mg/l. Nitrogen is also removed through microbial nitrification - deritrification, crop uptake and ammonia volatilization. Nitrification - denitrification dominates at recommended loading rates while crop uptake will become a major factor as the total annual nitrogen load drops toward that needed to satisfy the crop demand. For example, nitrification - denitrification will clearly dominate when the total annual nitrogen load is

2,000 pounds per acre; the annual crop demand is 100 pounds per acre; and the system is achieving 85 percent (1700 pounds) mass removal. Conversely, crop uptake will be a major factor if the total annual nitrogen load is 800 pounds per acre; the annual crop demand is 300 pounds per acre; and the system is achieving 90 percent (720 pounds) mass removal. It is comparatively easy to design and operate to achieve total nitrogen removals in the range of 70 to 90 percent based on total mass removal. It is more meaningful to use total mass removal as opposed to concentration reduction because there is substantial water loss to evapotranspiration and seepage. The effluent discharged (excluding rainfall input runoff) is usually 50 to 80 percent of the wastewater applied to the system.

Soil interactions with the clayey soils which make the best sites provides 40 to 60 percent phosphorus removal. The amount of removal may decline with time in service and varies according to the properties of the site soils. Several researchers have shown that phosphorus removal can be improved by chemical addition. One would predict that the accepted principals of phosphorus removal by chemical precipitation would apply to this fixed-film batch reactor as well as any other with one basic difference. The precipitated phosphorus is deposited on the soil surface to be incorporated into the soil rather than being removed as a sludge to be further processed for disposal.

We are also at a significant transition stage in the support and conduct of research on overland flow as a treatment technology. Laboratory, pilot and demonstration type studies are on the decline. It appears that we have sufficient confidence in our understanding of the basic concept to shift our attention to the gathering of information from full-scale operational facilities. One approach is use of "field tests" as established by the 1981 amendments to the construction grants provisions of the Clean Water Act. In my roles as National Coordinator of the innovative and alternative technology program, I have initiated an effort evaluate our current reservoir of design and operating information and to incorporate it into a supplement to the EPA design manual on land treatment. This effort is well underway and the supplement to the design manual should be available in October 1984.

DESIGN GUIDANCE

The consideration of overland flow in facility planning presents a specific and rather unique set of circumstances. As already mentioned, it is a developing technology and there is very little operational experience. Because of this lack of operating experience, State regulatory agencies may not have established criteria and guidance on design and operation. The fact that overland flow shows excellent capability to treat raw sewage presents a further complication. Application of raw sewage to the land is contrary to accepted environmental engineering practice. The idea of applying raw sewage to the land conjures up the historical health incidences associated with raw sewage farming with food crops in the 19th century. This practice of irrigating human food crops with raw sewage was justifiably abandoned because of unacceptable health risks. An educational and adjustment period is needed to provide operational experience for establishment of State criteria and to determine an appropriate match-up of preapplication treatment with the overall objective of specific projects. It is the common dilemma of which comes first — the horse or the cart — and it demands a position of flexibility for case-by-case determinations. This position allows simultaneous development of State guidance and adoption of developing technology as mandated by the innovative/alternative provisions of the Clean Water Act of 1977.

EPA guidance for preapplication treatment for overland flow which will qualify a project for construction grant funding is divided into two general levels that provide this needed flexibility.

The two levels of preapplication treatment recognize proximity of residents in an urban setting as an important factor in site selection. The lesser level of preapplication treatment specifies simple screening or comminution for overland flow in isolated areas without public access. The second level specifies a sufficient level of biological treatment to control odors and nuisance conditions in more urban locations with closer proximity of human habitation.

This EPA decision to set screening or comminution as a minimum level of preapplication treatment is based on results of several research and demonstration projects. There is a substantial amount of long term operational experience showing the excellent capability of overland flow to treat raw wastewater. Many operating facilities produce effluents with BOD and SS values of less than 20 mg/l when the applied raw wastewater has a BOD of more than 500 mg/l and SS in excess of 250 mg/l.

State guidance for overland flow is at an early stage of information and varies substantially from state to state. It is only within the last four or five years that many States have formulated a written policy on overland flow technology. In those States, overland flow is gaining acceptance as a practical, cost-effective and environmentally-sound alternative. Other States are looking at overland flow systems on a case-by-case basis until a larger data base is developed from first-hand experiences with overland flow systems within the State. It is important to be aware of the status of current state criteria when considering overland flow in facility planning.

DESIGN, OPERATION and MAINTENANCE

Transfer of research and demonstration results to practical design, operation and maintenance usually adds new dimensions to acceptance and implementation of a new technology. The initial group of full-scale systems serves as a field test to verify performance and to identify design features that facilitate better construction and easier operation. We are at that transition stage in the long range implementation of overland flow technology. There are some 35 to 50 systems in design, under construction or already in operation. A partial list of these systems is presented in Table 2. Systems listed were selected to show the distribution of geographic and climatic conditions represented by this initial group of full-scale systems.

Several of the eight systems which are listed as operational have already been studied to evaluate actual performance in relation to that projected at the time of design. Results from these studies are positive. Performance is consistent with design projections and previous research results. Reports of design features needing improvement to facilitate better construction and easier operation are comparatively minor and readily correctible with current knowledge. The fact that operators are very pleased with the ease that the systems meet discharge criteria is also encouraging. This encouraging result is countered by reports that systems do not discharge or discharge only part of the year. This may be the result of overly conservative design with the resulting high cost of excessive reserve capacity. The information gathered to date warrants an indepth study of design, construction and performance to ensure the appropriateness of future designs.

SUMMARY

My perspective for overland flow treatment of domestic wastewaters is a position of controlled optimism. Research results and limited operational data identify simplicity, energy savings, and low operating costs as major benefits. Overland flow is a good example of a developing technology which addresses the innovative/alternative aspects of the Clean Water Act of 1977. EPA continues to encourage consideration of overland flow in this context. Workshops such as this one and the continued research evaluation of newly constructed facilities will provide EPA, State agencies, and applicants up-to-date knowledge for improved design and operational reliability. Technical assessment of overland flow systems now operating, under construction or scheduled for construction will assist state agencies and applicants to keep pace with this rapidly developing tehcnology. EPA is confident that overland flow will become a popular and reliable wastewater treatment process. It is uniquely attractive to smaller communities who stand to benefit most from its simplicity lower cost and energy saving features.

REFERENCES

1. Thomas, R. E., K. Jackson, and L. Penrod. Feasibility of Overland Flow for Treatment of Raw Domestic Wastewater. Robert S. Kerr Environmental Research Laboratory. EPA Series No. 660/2-74-087, July 1974. 31p.

2. National Seminar on Overland Flow Technology for Municipal Wastewater. EPA-600/9-81-022, U.S. Environmental Protection Agency, Center for Environmental Research Information, Cincinnati, OH, 1981.

3. Process Design Manual for Land Treatment of Municipal Wastewater. EPA-625/1-81-013, U.S. Environmental Protection Agency, Center for Environmental Research Information, Cincinnati, OH, 1981.

4. Innovative and Alternative Technology Projects: A Progress Report. U.S. Environmental Protection Agency, Office of Water Program Operations, Washington, D.C., 1983.

Table 1: A Synopsis of Major Research Efforts

Project Location/Scale	Study Team	Wastewater Source	Principal Findings and Comments
Ada, OK Laboratory and field plot	EPA-RSKERL P.O. Box 1198 Ada, OK 74820	raw primary secondary	Overland Flow is a dependable technology to provide low-cost advanced treatment. Excellent removal of BOD, TSS and nitrogen. Moderate removal of phosphorus easily improved with chemical addition. Best results when applying raw wastwater. SS as algae is most difficult to remove. Bacterial indicators are reduced by 90 to 99% by overland flow. <u>Comment</u>: Up to 12 years of continuous use for some plots through sequential studies.
Hanover, NH laboratory and field plot	COE-CRREL 72 Lyme Road Hanover, NH 03755	primary secondary	Two years of study with emphasis on hydraulic detention time were used to advance a design theory. The theory represents other published data well. Study also provided good information regarding low temperature reduction of BOD removal under severe winter conditions. Also includes some initial information on removal of trace organics. Favorable removals were observed for a number of organics.
Vicksburg, MS and Utica, MS laboratory at WES and field plot at Utica, MS	COE-WES P.O. Box 631 Vicksburg, MS 39180	secondary effluent and lagoon effluent	Laboratory studies at the Waterways Experiment Station addressed removal mechanisms for laboratory at nitrogen, phosphorus and selected metals using amended secondary effluent from a package plant. Field plot studies with lagoon effluent at the Utica, MS site demonstrated that slopes ranging from 2 to 8% had little effect on treatment. SS as algae cells was effectively removed by using lower instanteous application rates. Reported 80 to 90% removals for cadmium, nickel, copper and zinc at these slower rates.

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Project Location/Scale	Study	Source	Wastewater Principal Findings and Comments
Easley, SC Field Demonstration and full-scale	SC-DHEC and Environmental Systems Engineering Department Clemson University Clemson, SC, 29631	Raw lagoon Effluent	Demonstrated overland flow for treatment of raw comminuted sewage (25,000 gpd) and lagoon effluent (75,000 gpd). Both systems met or exceeded typical secondary systems with consistent quality of effluent. Best removals when raw sewage was the source and removal of algae SS was most difficult. Comment: The system is scheduled to continue as a full-scale operational system treating lagoon effluent.
Davis, CA indoor piolt studies and field demonstration	Department of Civil Engineering University of California, Davis Davis, CA,	synthetic primary secondary	Semicontrolled pilot studies in the laboratory were coupled with a follow up field demonstration to develop design theory and verify design for the full-scale facility to treat 5 mgd. Design theory is based primarily on detention time as influenced by slope dimensions and application procedures.
Moodna Basin Hariman, NY field plots	Phillip J. Clark Engineers and Consultants, PC New York, NY, 12205	primary secondary	A facility plan pilot test to verify design of overland flow as one of the alternatives under consideration for an expansion and upgrade of existing facilities. Fifteen months of data on BOD, SS, nitrogen and bacteria in a cold climate including winter operation led to conclusion that overland flow could be operated successfully to meet secondary in winter and achieve tertiary in summer.

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Carbondale, IL full-scale for trailer park	School of Engineering and Technology University of Southern Illinois Carbondale, IL, 62901	lagoon effluent	Studies assessing the effects of high hydraulic loading and slope lengths showed 60 to 85 percent removal of BOD after 60 to 100 minutes of retention time. Comment: The results of this study show the same comparatively broad peak of good performance at loadings of 10 to 50 inches per week as others observed at loadings as low as 2 inches per week.
Pauls Valley, OK Field demonstration	State Health Department Oklahoma City, OK 73152 and Health Sciences Center University of Oklahoma Oklahoma City, OK 73190	raw and pond effluent	Treatment of raw wastewater demonstrated the ability to achieve BOD and SS removals better than conventional secondary under winter and summer operation. Temperature was shown to have a direct effect on removal efficiency. Treatment of the lagoon effluent provided limited benefits as an advanced treatment process. There was 100% virus removal for the raw system. Airborne bacteria were greater in downwind samples but no viruses were isolated in air samples.
Baton Rouge, LA laboratory	Center for Wetland Resources Louisiana State University Baton Rouge, LA 70803	simulated	These carefully controlled studies showed that ammonia volatization was a minor mechanism in nitrogen removal as it accounted for about 5% of the removal. Nitrification - denitrification and crop uptake could dominate depending on the total nitrogen load to the system.

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Project Location/Scale	Study Team	Wastewater Source	Principal Findings and Comments
Logan, UT field plots	Utah Water Research Laboratory Utah State University Logan, UT, 84322	lagoon effluent	This brief three month study on newly established plots during the fall season showed no BOD or SS removal at loading rates of 2 to 6 inches per week. Comment: Work at other locations has demonstrated the need for several months of system conditioning to ensure stable conditions for evaluating performance.
Laramie, WY field plots	Department of Agricultural Engineering University of Wyoming Laramie, WY, 82070	lagoon effluent	Preliminary results from the first year of study support previous work which had projected that start up and operation in cold climate winter conditions could present formidable design challenges.
Paw Paw, MI field test and full-scale	William & Works P.O. Box 6510 Grand Rapids, MI, 49506	raw pond effluent	Field site for study has been prepared and is being conditioned with wastewater applications. applications. Spring of 1984 will initiate period of wastewater application under stabilizing conditions for evaluation of performance.

Table 2: A Selected List of Overland Flow Systems

Community,State	Design Flow (MGD)	Design Consulting Firm
Alma, AR	1.27	-
*Alpine, AZ	—	Ellis, Murphy & Holgate
Arcadia, LA	0.515	Balar and Assoc.
Castor, LA	0.03	S.M. Cothren
Cleveland, MS	3.0	Clark Dietz Engineers
Corsicana, TX	1.0	Gilbreth & Assoc.
*Davis, CA	5.0	Brown & Caldwell
*Easley, SC	0.1	-
Esterwood, LA	0.018	Alex Theriot, Jr. & Assoc.
*Falkner, MS	0.04	-
Forrest Hill, LA	0.06	Alex Theriot, Jr. & Assoc.
Franklinton, LA	0.74	N-Y & Assoc.
Hall Summit, LA	0.056	Alex Teriot, Jr. & Assoc.
Heavener, OK	0.45	Alford Engineering Co.
Kenbridge, VA	0.3	Environmental Technology Consultants, Inc.
*Lamar, AR	0.11	Burrough, Verling, Braswell, Inc.
Morse, LA	0.09	Alex Theriot, Jr. & Assoc.
*Mt. Olive, NJ	0.02	-
*Newman, CA	--	Brown & Caldwell
Norwalk, IA	0.6	-
Norwood, LA	0.035	US Environmental Planners
Oppelo, AR	0.12	Affiliated Engineers
*Santa-Fernwood, ID	0.1	J-U-B-Engineers
Vinton, LA	1.0	Roy F. Weston
Wabbaseka, AR	0.104	Affiliated Engineers

* systems reported to be operational