EFFLUENT IRRIGATION: IMPLICATIONS FOR NATURAL SYSTEMS MANAGEMENT

Linda Handley
Department of Botany
University of Hawaii at Manoa
Honolulu, Hawaii 96822

INTRODUCTION

The United States is one of a few countries in the world which has been able to afford to throw away nitrogenous wastes. Disposal in this sense has resulted not only in foolish economic management but also eutrophication of water bodies. Disposal in the sense of wastewater irrigation is disposal without degradation of the environment and, in some cases, with enhancement of the environment. In this talk I propose that wastewater irrigation could also become a valuable tool for habitat manipulation and natural systems management.

DISCUSSION

Wastewater irrigation can provide a number of advantages over traditional disposal methods. It converts a point source of pollution into a useful source of nutrients (mainly N and P) and irrigation water. In some cases it has been used to reclaim strip-mined land for agriculture. There can be a substantial savings over purchasing chemical fertilizers. For some crops, wastewater is a more efficient source of nitrogen, producing crops with a higher protein content (Day et al. 1975) than use of the equivalent amounts of chemical fertilizer. The method can provide a cost-effective means of waste disposal under a variety of conditions (Gosselink et al. 1974). Waste irrigation can provide groundwater recharge, using the plant/soil system as a "living filter" for replenishment of pure drinking water. This is especially relevant to Hawai'i since Lau (1978) and others have demonstrated that there may be a shortage of potable water by the year 2000 if alternate sources and/or reuse methods are not employed. Finally, a crop can be produced on otherwise marginal agricultural land.

Problems

This approach is not without problems. Unlike many technological methods, its use must be designed on a case-by-case basis. The first major thrust for wastewater farming in the western world came in 1865 (Wolman 1977) when a British commission was formed to alleviate pollution in the Thames River and other streams, pollution caused by the then new vogue of "water closets." This was followed by similar efforts in the United States and parts of Western Europe. Unfortunately, at the time little background information was available for proper site and crop selection. Little was known about epidemiology, the nature of nutrient cycling, the relations of soil structure and its responses to the method, as well as the need for a suitable climate. Wastewater farming was begun enthusiastically but not very discriminately, often in areas where rainfall was too heavy, where soils soon clogged under the influence of heavy sodium loadings; these factors, often combined with cold winters, made some projects a failure and the impetus was lost.

Hawaiian Agricultural Research

Enough background information is now available to apply wastewater irrigation more rationally and, in particular, enough is known now about Hawaiian conditions and wastewater application to croplands in the State that many of the undesirable side-effects of previous attempts can be avoided. Lau (1978) enunciated some general guidelines for wastewater reuse in Hawai'i. These are:

1. EFFLUENT QUALITY REQUIREMENT

    a. Secondary treatment & chlorination where necessary;
    b. Domestic and municipal origin;
    c. Minimal toxic chemicals;
    d. Low concentration of total dissolved solids, boron, suspended solids, & grease;
    e. Reasonably consistent quality over time.

2. SOILS AND CROPS

    a. Soils suitable for crop growth;
    b. Soils with high sorptive capacity and high iron oxide preferred;
    c. ~~Crops with high tolerance to N and/or salinity;~~
    d. Grass, such as Bermuda grass (*Cynodon dactylon* (L.) Pers.), with thickly matted root system;
    e. Vegetable crops that are generally eaten cooked.

3. IRRIGATION AND FERTILIZATION

    a. Maintain no-water stress condition;
    b. Apply no excess for pollution control assuming effluent is not too saline to require leaching;
    c. Provide storage or bypass for non-irrigation periods;
    d. Provide, in the case of sugar cane, commercial fertilizers to give cane fast growth start.

4. GEOHYDROLOGIC CONSIDERATIONS

   a. Conduct a geohydrologic survey to ascertain potable pathway of deep percolation, to determine groundwater occurrence, circulation, quality, recharge, and discharge;
   b. Select areas of minimum soil thickness of 2 m with high adsorptive capacity;
   c. Determine minimum allowable depth to water table on case-by-case basis of geology and potable groundwater quality.

5. MONITORING FACTORS

   a. Selective monitoring of chemical, microbiological, and viral water quality, including STP effluent, leachate, and groundwater;
   b. Selective monitoring of soil in terms of chemical properties and viruses;
   c. Monitoring of crop growth and yield.

Natural Areas

Thus, we have some criteria for wastewater farming in Hawai'i. But I know of no research in the tropics on wastewater irrigation in natural systems. Many of the above-mentioned criteria will undoubtedly apply but with added criteria for species interactions, use on non-agricultural soils, and nutrient cycling capacity of the systems under study.

The little we do know is from temperate regions and only emphasizes the need for research in the tropics. The lesson from temperate regions is that system response is highly variable. Woodwell (1977) and others have shown that in a mature hardwood forest of the temperate United States (e.g., Brookhaven, N. Y.) such irrigation can drastically alter the composition of the plant community. Similar alterations can be inferred to affect grasslands. This inference comes from numerous pasture fertilization studies. Marshes, on the other hand, tend to increase in net primary production but remain stable in community composition (Valiela et al. 1976). Cypress swamps are now known to be poor re-cyclers of this kind of nutrient loading (Odum 1975). Woodwell (1977) has made some generalizations about systems in temperate North America (Fig. 1). He has concluded that, in general, older successional stages are less "leaky" with respect to nutrients than younger stages. That is, they recycle nutrients more efficiently with less loss from the system. However, these generalities should not be extrapolated wholesale to Hawaiian conditions or systems since they involve different plant cover, soil types, and climate.

There has also been some work done in temperate climates on silviculture fertilization with wastewater (Steinbeck 1976). In general, the best level of irrigation varies with the type of timber crop and the soil type. For example, red pine grown on sandy loam is a poor candidate, growth being suppressed at levels of irrigation which are desirable for other tree species and soil types (Sutherland et al. 1974). Other plantation stands showed increased survival rates, productivity, and vigor.

Here in Hawai'i at least one natural terrestrial system is used now for receiving large amounts of effluent. This is Kawainui marsh in Kailua, on windward O'ahu. That system seems well able to handle the loadings put into it. However, this is not the result of planning but, rather, the serendipitous result of a marsh's resistance to nutrient loading. Other types of systems cannot be expected to respond to this particular type of stress in the same way. Experience in temperate regions has shown this to be true.

With the proper background information, effluent irrigation could be developed as a valuable natural areas management tool, not only for timber and biomass production but also for habitat enhancement. It might be used deliberately to encourage the growth of certain components of the plant community, while suppressing others. Some carefully selected areas of watershed might be subjected to wastewater irrigation for both groundwater recharge and habitat manipulation. This is certainly a reasonable possibility for the not too distant future. However, before this method can be applied on any large scale to natural systems, one would need the predictive results of experimentation with a variety of plant cover types, soils, and climates.

Immediate Prospects

By 1981 at least one sugar company on O'ahu will be irrigating with diluted wastewater. The method has also been proven for use on golf courses and might be used for other public areas such as highway rights-of-way. Some cane fields on West Maui have used this type or irrigation since 1967, this case being a response to water shortages. Recently the City and County of Honolulu recommended intensive irrigation of californiagrass (*Brachiaria mutica* (Forsk.) Stapf) as a preferred disposal method for semi-rural areas. One cut-flower grower is also using effluent irrigation on central O'ahu.

At least for the present, the method seems confined in Hawai'i to agricultural or horticultural use. This is as it should be, until more is known about its effects on less intensively managed systems. However, the prospects for using it as a systems management tool are enticing, for habitat manipulation, for biomass and timber production.

CONCLUSION

It is known already that fertilization can enhance the production of managed natural systems and that community structure can be affected. Plant response to effluent irrigation is also slightly different compared with equivalent amounts of chemical fertilizer. These facts, combined with the guidelines provided by wastewater farming in Hawai'i, suggest wastewater irrigation as a possibly valuable management tool. The key component to such use is, nevertheless, applied field research and an adequate backlog of information from controlled pilot studies.

LITERATURE CITED

Day, A. D., F. A. Taher, and F. R. H. Katterman. 1975. Influence of treated municipal waste water on growth, fiber, acid solid nucleotides, protein, and amino acid content in wheat grain. J. Environ. Qual. 4: 167-169.

Gosselink, J. G., E. P. Odum, and R. M. Pope. 1974. The value of a tidal marsh. Center for Wetland Resources. Louisiana State University. LSU-SG-74-03. Baton Rouge. 30 pp.

Lau, L. S. 1978. Land treatment and reuse of sewage effluent by irrigation: A perspective for Hawaii. U. S. Environmental Protection Agency. EPA-430/9-78-005. Washington, D. C. 45 pp.

Odum, H. T. 1975. Cypress wetlands for water management recycling and conservation. Annual Report to National Science Foundation. Center for Wetlands. Univ. Florida. Phelps Lab. Gainesville, Florida. 948 pp.

Steinbeck, K. 1976. Biomass production of intensively managed forest ecosystems. Pages 35-46 <u>in</u> H. G. Schlegel and J. Barnea, eds. Microbial energy conversion. United Nations Seminar held in Göttingen, W. Germany.

Sutherland, J. C., J. H. Cooley, D. G. Neary, and D. H. Urie. 1974. Irrigation of trees and crops with sewage stabilization pond effluent in southern Michigan. Pages 295-313 <u>in</u> Wastewater use in the production of food and fiber-proceedings. Robt. S. Kerr Environmental Research Lab. PB-245=176. Ada, Oklahoma. 568 pp.

Valiela, I., S. Vince, and J. M. Teal. 1976. Assimilation of sewage by wetlands. <u>In</u> M. Wiley, ed. Estuarine processes. Vol. 1. New York: John Wiley & Sons.

Wolman, A. 1977. Public health aspects of land utilization of wastewater effluents and sludges. J. WPCF. Nov.: 2211-2218.

Woodwell, G. M. 1977. Recycling sewage through plant communities. Amer. Sci. 65: 556-562.

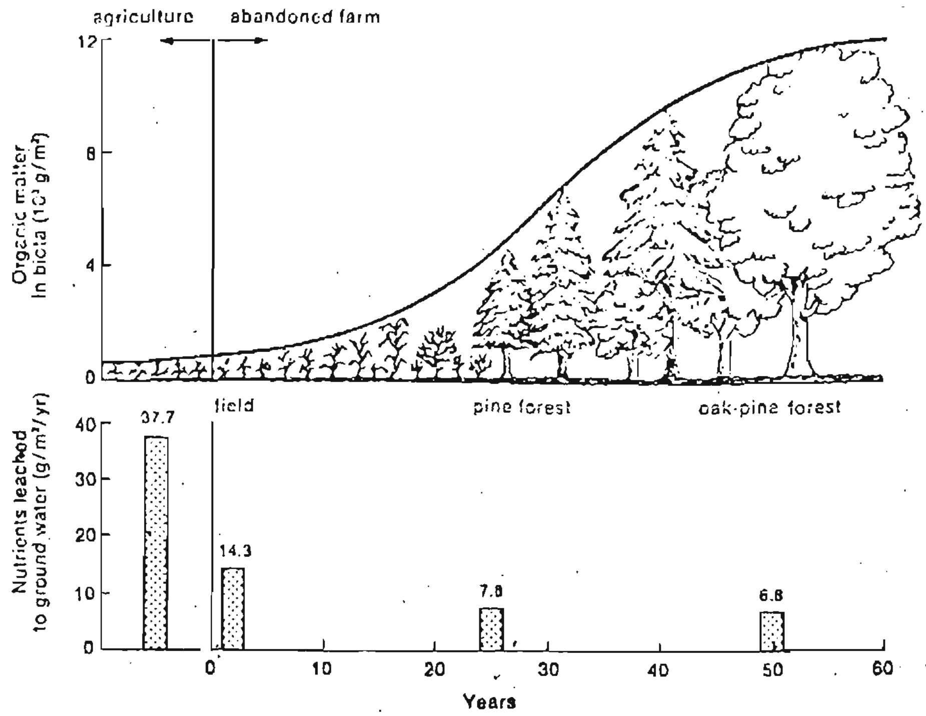

FIGURE 1. Graph illustrating the effects of different ecosystems on the quality of groundwater in the eastern deciduous forest zone of North America. Nutrient losses are high in the earlier stages of succession because of the use of fertilizer in agriculture, which increases the availability of mineral ions, and because the plant communities of those stages have a low capacity for retaining nutrients. From Woodwell 1977.