AN INTEGRATED SYSTEM EMPLOYING ALTERNATIVE TECHNOLOGIES FOR LIQUID AND SOLID WASTE MANAGEMENT FOR INTERMEDIATE AND SMALL COMMUNITIES

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Over the past 20 years, a variety of alternative, and in many cases innovative, technologies have been proposed for use in waste management systems. If alternative technologies are to be adopted they must, 1) be technologically feasible, 2) minimize the use of energy and resources, 3) maximize the recovery of the energy and nutrients contained in wastewater, 4) be cost-effective, and 5) not be unnecessarily disruptive of the existing order in their implementation. Although a number of the proposed technologies have met some or all of these requirements, few of them have been widely adopted. The principal reason that they have not been accepted more readily is that they were never incorporated into or presented in the context of an integrated waste management system. It is the purpose of this paper to present and document a workable integrated system for waste management for intermediate and small communities involving the use of several new technologies. The technologies to be considered in this analysis are all currently under development and study at the University of California at Davis. It is the objective of this paper to stimulate further discussion on the subject of alternative technology and its potentials.

The alternative technologies to be considered include: 1) the use of aquatic systems for wastewater treatment, 2) land treatment systems, and 3) the use of the gasification process for the production of a low Btu gaseous fuel. The interrelationship of these technologies, in the context of an integrated waste management system is shown in Fig. 1. Additional technologies that can be incorporated in the future are enclosed within a dashed line. Intermediate and small communities are emphasized because the need for economic alternative technology is greatest in these communities, and they are usually situated in locations where the use of land based systems is feasible.

AQUATIC SYSTEMS FOR WASTEWATER TREATMENT

The purpose of wastewater treatment is to reduce the concentration of the contaminants added to the water supply as a result of municipal usage to levels that are acceptable

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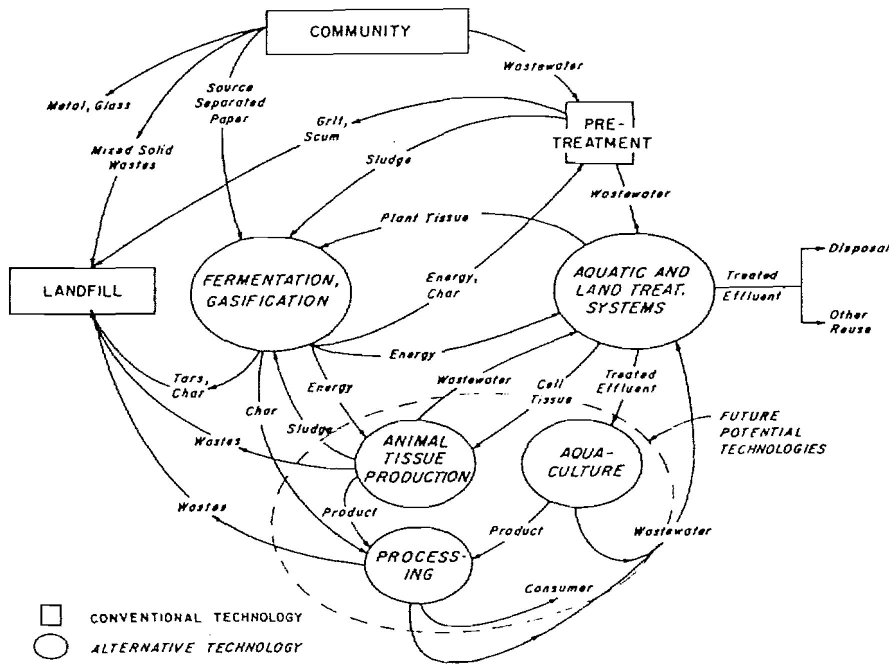

FIGURE 1
AN INTEGRATED WASTE MANAGEMENT SYSTEM
EMPLOYING ALTERNATIVE TECHNOLOGIES

as dictated by the ultimate use of the treated effluent or the applicable discharge requirements. At present, most conventional treatment systems are energy intensive and expensive, especially for small communities because system costs do not decrease proportionately with reductions in system size. During the past ten years, a number of alternative processes employing aquatic plants and animals have been proposed for use in the treatment of wastewater. With proper development, the use of aquatic plants and animals may offer a low-cost, low-energy method of treating wastewater and, at the same time, allow for some energy and nutrient recovery.

Characteristics of Aquatic Systems

Conventional and aquatic systems have two important differences. First, aquatic systems contain a greater variety of natural absorptive and adsorption surfaces that have the potential to retain a wide spectrum of wastewater contaminants. Second, the solids "harvested" from aquatic systems are macroscopic in size and may contain up to 20 percent solids. Operative removal mechanisms in aquatic systems for the contaminants found in wastewater include: sedimentation, biological conversion, absorptiom, and adsorption. Operationally, the cumulative contaminant loading can be controlled by removing vegetation and/or substrate.

The fundamental unit of an aquatic treatment system is the aquatic processing unit (APU). An APU is defined as the assemblage of aquatic organisms grouped together to achieve a specific treatment objective (e.g., nutrient and heavy metal removal). In this context, an APU is a definable physical entity that represents some discrete step in the treatment of a wastewater. For example, several APUs could be used together to form an aquatic treatment system or one or more could be used in conjunction with conventional treatment methods to achieve a desired degree of wastewater treatment. The conceptual use of APUs to accomplich various wastewater treatment objectives is illustrated in Fig. 2.

The APUs used in the flowsheets shown in Fig. 2 are arranged so that the application is from least to most complex. For example, in Fig. 2a, the APUs are used for the removal of nutrients and heavy metals. In contrast to this relatively simple application, the complete treatment of wastewater with an APU is envisioned in Fig. 2e. Still more complex is the flowsheet in which an APU is used for the complete treatment of wastewater (Fig. 2g), including the removal and disposal of solids handled by the primary treatment facilities used in flowsheets 1a through 1e.

At present, what little is known about the use of plants (and animals) for the treatment of wastewater is related primarily to the removal of nutrients (nitrogen and phosphorous) and heavy metals from conventionally treated effluent (Figs. 2a through 2c). While this information is of value, research is needed to define the conditions

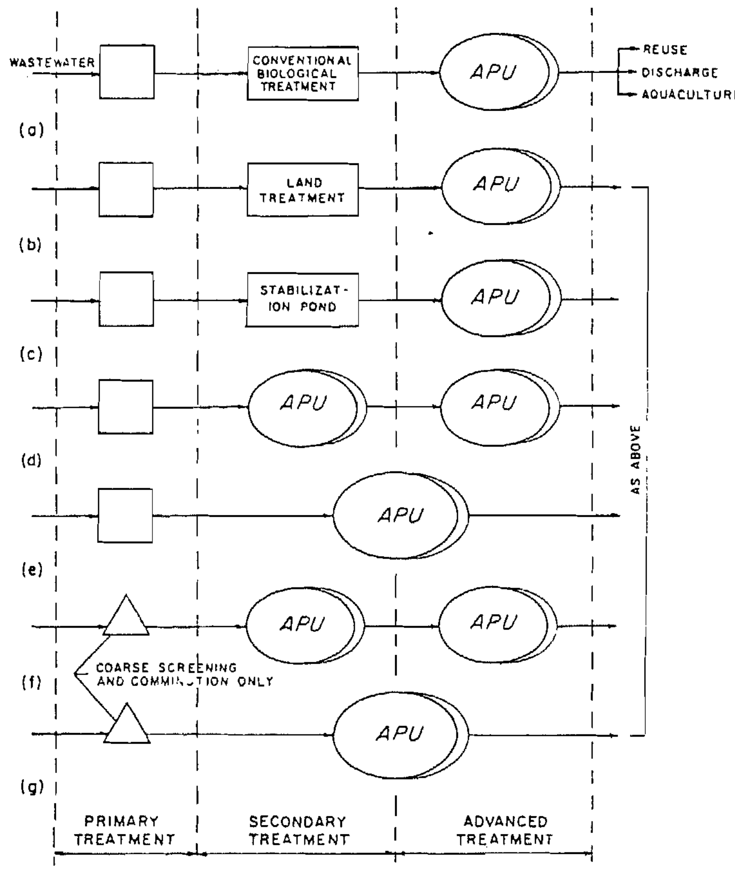

FIGURE 2

APPLICATIONS OF AQUATIC PROCESSING UNITS
FOR THE TREATMENT OF WASTEWATER

under which various types and combinations of aquatic species may be used in various types and combinations of APUs to accomplish primary, secondary, and advanced levels of wastewater treatment (Figs. 2d through 2g).

Applications

In practice, APUs will contain different types and combinations of aquatic species, be managed or operated in different ways, and have different physical features depending on the function of the APU in the treatment system. While a low-energy unmanaged system is desirable, some level of control may be required because of environmental conditions or to meet treatment objectives. As an example, a desirable plant species may not reproduce in certain climates. Consequently, nursery and planting operations may become part of the treatment system if these plants are to be used. In another case, a particular harvesting procedure may be necessary to accomplish the treatment objectives assigned to the APU. In still other cases, the APU environment may have to be controlled using physical features such as greenhouse, oxygenation systems or impervious substrates to achieve the function of the APU. At this time, the tremendous variation possible in APUs is a point of confusion, but as the performance of selected APUs is defined, this flexibility in the selection of APU type should become an asset in the design of aquatic treatment systems for different locations.

LAND TREATMENT

Treatment of wastewater by application to land is an attractive alternative for small and intermediate size communities that are located near suitably sized areas of undeveloped or agricultural land. Land treatment offers several advantages to the small community. A minimum of operator attention and training are required to operate most systems. Processes are not subject to upset due to variation in wastewater characteristics. High l vels of treatment are achieved with no production of waste solids. Land treatment systems are compativle with any conventional and aquatic treatment process and may be used to upgrade existing systems. There are three general categories of land treatment methods that are suitable for different types of soil and subsurface geologic conditions - slow rate, rapid infiltration, and overland flow.

Treatment Methods

Slow rate systems are suitable for sites having moderately slow surface and subsoil permeabilities. Wastewater is applied at a sufficient rate to meet the evapotranspiration demand of a crop or vegetative cover plus a leaching requirement. That portion of the wastewater that percolates beyond the root zone undergoes treatment by a variety of mechanisms as it passes through the soil matrix. Percolated water may be recovered with underdrains if desired. Average application rates do not exceed 10 cm/wk. Wastewater is subjected to primary settling or oxidation prior to application.

Rapid infiltration systems are suitable for sites having rapidly permeable surface and subsoils down to underlying groundwaters. Application rates exceed 10 cm/wk. Most of the applied wastewater percolates through the subsoil to the groundwater, and treatment is achieved during percolation. The percolated water may be recovered by wells or under-drains for direct reuse or it may be allowed to mix with the natural groundwaters and augment existing supplies. Wastewater is generally subjected to oxidation prior to application.

Overland flow is suitable for sites having very slowly permeable soils or subsurface barriers that restrict the overall soil system permeability. The soil surface is sloped usually between 2 and 6 percent to promote surface drainage. Most of the applied water appears as runoff and treatment is achieved on or near the soil surface as the wastewater flows in a thin sheet down the slope. Treated effluent is collected at the bottom of the slope. Overland flow may be used to treat raw, primary settled, or oxidized wastewater.

Applications

Effluent recovered from any of the three types of land treatment systems is comparable in quality to effluents from conventional in-plant advanced wastewater treatment systems employing nutrient removal and filtration. Thus, effluents are suitable for several forms of reuse including general irrigation, recreational lakes, aquaculture, and industrial processes. As shown in Fig. 1, harvested plant biomass can be combined with source separated paper wastes to produce energy. If the gasification process is used, the volume of material that must be disposed can be reduced by more than 90 percent. The resulting char can also be used (see Fig. 1).

GASIFICATION

Gasification is a process in which a carbonaccous fuel is partially combusted to generate a combustible gas rich in carbon monoxide and hydrogen. Developed in the early 1800's, gasifier technology had advanced by the early 1900's, to the point where virtually any type of cellulosic residue such as rice hulls, olive pits, straw, and walnut shells could be gasified. Early gasifiers were used to provide fuel for stationary engines.

Gasification Practice

Acual composition of the combustible gas that is produced is dependent upon the temperature of the reactor and the fuel moisture. Typically, the gas contains about 10% CO_2, 20% CO, 15% h_2, 2% CH_4, with the balance being N_2. The energy content of the gas is in the range of 140-160 BTU/scf. At present, four types of reactors are used in gasification systems: (1) vertical packed bed, (2) multiple hearth, (3) rotary kiln, and (4) fluidized bed. Although more sensitive