Nutrient Assimilation by Algae in Waste Stabilization Ponds

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Effects of Waste Disposal

Every community is confronted with the need for disposing of the accumulation of wastes of various kinds, and one of these that often produces unique problems is sewage. Because of its unstable nature, sewage must be removed quickly and continuously. A common practice in most communities is to dispose of it, with or without previous treatment, into a nearby stream, which carries the material away from the area. This addition of sewage or sewage products to the stream often creates problems for a downstream community that depends upon this source for its water supply.

There are many variations in the methods used for disposing of sewage. Reducing at least the soluble organic portion of sewage to inorganic salts and releasing them into a stream is a very common method. This approach has the disadvantage of stimulating uncontrolled algal growth in the stream. The algal bloom is followed by a series of changes, which may be on too large a scale for the amount of water available, and which, therefore, may result in esthetically undesirable flora, fauna, and water quality. Limitations may also be imposed upon the uses of a stream and the activities it could accommodate.

An even more damaging effect occurs where raw, mostly undecomposed sewage is released into a stream; septic conditions that are not overcome for some distance downstream are often produced. As the polluted water flows downstream, bacteria, algae, and other organisms help to gradually bring about a "natural purification" and the worst undesirable conditions disappear (5). With rapidly increasing demands for the use of streams for agriculture, recreation, industry, and water supplies for new and enlarging communities, long stretches of stream reserved for self-purification are becoming fewer.

Use of Stabilization Ponds

Methods must be developed for more complete treatment of sewage before the effluent is released. One of these methods involves the use of sewage stabilization ponds (22). Others include tertiary treatment, segregation of wastes that require special treatment, and recovery for use of some materials that were formerly discarded.

The waste stabilization pond involves the construction of an artificial pond or the setting aside of a suitable natural pond or lagoon. The liquid sewage, released into the pond either before or after preliminary treatment, is held there to permit desired microbiological transformations to take place (20). Algae, bacteria, and other microorganisms combine to change the waste into stabilized forms, which are unobjectionable to the community. The process itself can also be so regulated that no offensive conditions occur during the treatment (16).

This procedure has been accepted in many areas as a legitimate and satisfactory method for disposing of sewage and some types of industrial wastes (6). In a few states up to one-half or more of the communities have adopted this method of treating their wastes (24). Several of these ponds are in use in Indiana (Plate I). There are disadvantages and limitations as well as advantages to this method; these will be dealt with later.

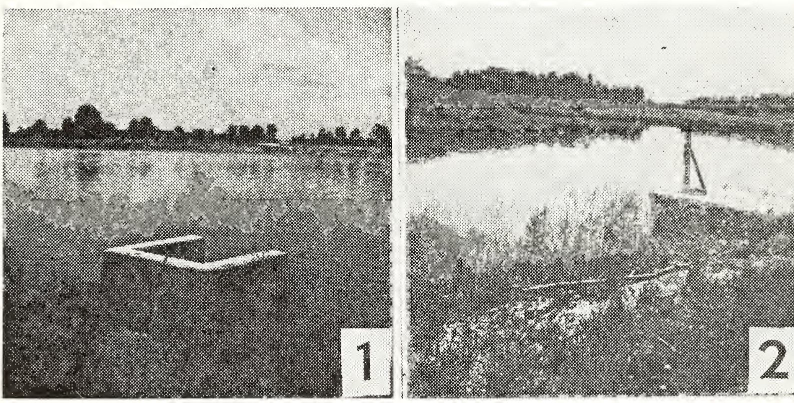

PLATE I

Sewage stabilization ponds showing outlets.

1. Napoleon, Indiana
2. Sunman, Indiana

—Photos by R. S. Safferman

The transformations in a stabilization pond correspond closely to the natural purification in a stream that receives organic wastes. Aerobic and anaerobic saprobic bacteria are available to act upon the organic debris in the water and to break down the material into simpler compounds. In the presence of sufficient quantities of sewage, any dissolved oxygen in the water may be consumed very quickly. The activities of the aerobic bacteria are generally limited in scope by the decreased amount of oxygen in the water to be used, and the aerobic process, therefore, comes to a standstill. In many cases, however, it is desirable to encourage the aerobic process and to limit the anaerobic, since the former can be faster and the amount of intermediate malodorous products is less than in the latter process (15).

Algae, Oxygenation, and Stabilization

When algae are present in the pond they release excess oxygen into the water by photosynthesis. This oxygen is then available to increase the aerobic decomposition of the organic wastes by bacteria. The aerobic treatment of the sewage is thus accelerated (2).

Although many kinds of algae are sensitive to large amounts of organic wastes in their environment, others are tolerant and may be stimulated in their growth and reproduction by the presence of the wastes. The latter forms are often spoken of as the pollution-tolerant algae, or merely the pollution algae (17).

The algae function in another significant way in the pond. The simpler compounds resulting from the decomposition of organic wastes by aerobic bacterial activity includes nitrates, ammonia, phosphates, and lesser amounts of other compounds, all of which happen to be the nutrients required for growth by algae (10). The pond water does not accumulate any large quantity of these nutrients since they are quickly absorbed and assimilated by the algae. In this way, the chemical units formerly comprising the organic wastes eventually are incorporated in the algae as relatively stabilized organic components of living algal cells (4).

Considering the two functions of the algae, the ponds may be called "oxidation" ponds if the release of oxygen by algae is emphasized, or they may be called "stabilization" ponds if the assimilation of stable living algal substances is emphasized (18).

When the algae in the ponds die, their organic contents are subject to decomposition by saprobic bacteria. The death and decomposition at one time of large numbers of algae would again bring about nuisance conditions approximating those caused by the original sewage wastes placed in the pond. It is desirable, therefore, to prevent this by stimulating the algae to continue growing or by arranging for the algae to leave the pond continuously in moderate numbers (19).

The sewage stabilization pond permits control of a number of factors that affect the efficiency of treatment. The capacity of the pond should be determined to permit optimum concentration of sewage in water and optimum holding time. A shallow depth, often about 4 feet, is used so that sunlight may reach even the lower layers of water and thus allow algal photosynthesis throughout the pond. The movement of water through the pond is controlled by regulating the effluent rate. It must also be determined whether to use the pond for complete, secondary, or tertiary treatment of the sewage. Some states have statutes that regulate the use of the ponds and restrict them for one of the three treatments listed above (7).

Harvesting of Algae for Commercial Products

Since the algae represent a concentrated mass of proteins, fats, and carbohydrates, there has been much recent interest in experimenting with methods of harvesting the excess algae in the ponds and testing them for possible commercial use. Potential algal products include fuel, fertilizer, poultry feed, cattle feed, fish food, human food, pharmaceutical materials, and enzyme extracts (23). Because of their very rapid growth and multiplication, and their lack of fibers and other inert tissues, algae represent a highly concentrated, relatively pure mass of usable organic material that can be produced continuously, quickly, and cheaply while serving at the same time as a means of processing unwanted community wastes (8).

One of the serious drawbacks in the production of commercial algal products is that all methods tried for harvesting algae are quite costly. These methods include straining, centrifuging, drying, flotation, coagulation, sedimentation, and chemical extraction. In many cases, two or more of these methods have been combined. There is a continuing interest in finding an economical method of separating these minute organisms from the culture medium (12).

Another problem in producing a commercial product of high quality is the inability to grow a crop of algae having consistent composition and texture. At present, predetermining the particular kind of algae that will predominate in the pond is not possible. This means that the composition of the harvested product will vary according to the kinds of algae that happen to be abundant in the pond. These may change from week to week, and thus change the composition of the product.

Uses for Effluent

Regardless of whether the algae are to be utilized commercially, some communities are interested in reuse of the effluent water of the pond. This water might be made acceptable for various industrial uses and for irrigation of crops. Water is being prepared also for recreational lakes suitable for boating, water skiing, fishing, and swimming. When used in this way, it is treated with a germicidal agent such as chlorine to destroy pathogenic microrganisms that may have survived from the sewage (9).

Kinds of Algae Involved

A study of several sewage ponds in widely scattered parts of the United States, including three in Indiana, indicates that there are more than a dozen genera of algae, any one of which may be a frequent and dominant constituent of the flora. Only one of these is a diatom, and only two are blue-green algae. Three are pigmented flagellates; the remainder are nonmotile, nonfilamentous green algae. Practically all of these tend to be planktonic, that is, they remain dispersed in the water and are unattached to other objects (21). Most of them do not tend to collect on the surface as a mat or bloom. They are well equipped in form and distribution to absorb sunlight and nutrient salts and to release oxygen throughout the length and depth of the pond (1). Algae that would concentrate as mats or blooms on the surface would be undesirable because they would release oxygen into the air above rather than into the water.

A few of the sewage pond algae have the unusual capacity of being able to absorb organic compounds rather than the inorganic salts. These algae produce little oxygen and are therefore inefficient in stimulating aerobic bacteria to act upon the sewage (11).

Several of the algae are unable to develop in the presence of large amounts of certain organic wastes such as those from milk processing plants and beet sugar factories (13). At other times the algal population may be radically reduced in numbers by small aquatic animals, particularly daphnia, which may develop in large numbers and consume the algae as food. These examples help to emphasize the significant problems that can be expected to arise, at least occasionally, when sewage stabilization ponds are used.

Advantages and Limitations of Waste Bonds

The advantages of treatment of sewage by means of stabilization ponds have been sufficient to cause them to be installed in many places. The process can be a relatively inexpensive method for satisfactory disposal of sewage, both as to cost of installation and of maintenance. It can make possible the eventual use of the effluent water and the algal mass. It appears to have an antibiotic effect that reduces intestinal microorganisms. Pollution of streams with unstable organic materials or with algal nutrients is greatly reduced. The sewage pond has found its place more often in small communities where sufficient area is available and reasonable in price. It is particularly promising where water reuse is in demand, where there is an interest in the harvesting of the algae, or where prevention of stream pollution is important (14).

There are some disadvantages and limitations in the use of a stabilization pond. The large area required often makes the acquisition of sufficient acreage for the ponds too costly. Control of midge flies and other flying insects that may breed in the ponds and become an annoyance to the community may be difficult. Certain industrial wastes may interfere with the desired biological activities in the pond. Most of the disadvantages apply particularly to the larger cities and towns (3).

Summary

The natural science approach to assimilation of nutrients involves the use of aquatic microorganisms to decompose unwanted wastes and to permit the products of decomposition, after absorption and assimilation by algae, to form cell substances that tend to remain in a stabilized condition. In this form they are not objectionable and may even be harvested to become products useful to man. The process is also a method of reducing pollution of streams.

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