SEWAGE LAGOONS IN THE ROCKY MOUNTAINS[1]

David P. Green

Wyoming Department of Public Health, Cheyenne

The sewage lagoon or oxidation pond has become a very popular method of waste treatment. Since 1954 47 municipalities have constructed or are in the process of constructing this type of waste treatment system, while only four conventional type plants have been built during the same period.

Advantages and Disadvantages

The oxidation pond is certainly not a cure-all for the problems of sewage treatment. Used intelligently, it may be a very satisfactory and economical method of sewage treatment. Unfortunately, there is a growing tendency to overlook the necessary evaluation of any specific case and to recommend a pond immediately. The ponds do have a number of advantages where correctly used. Included in these are:

1. Low capital investment.
2. Low maintenance cost.
3. Low operational cost.
4. Simplicity of design.
5. Inherent ability to withstand shock loading.
6. Extremely high degree of treatment during warm months, and a reasonable degree of treatment even during the cold months.

There are always disadvantages to go with advantages. The more important of these are:

1. Land cost must be low.
2. Location of a satisfactory site may be difficult, particularly when the direction of growth of a municipality is considered.
3. Esthetic problems brought about from both detractors and over-enthusiastic supporters of this method of treatment.

These factors must all be carefully evaluated prior to deciding upon the lagoon method.

Types of Lagoons

Insofar as the lagoon itself is concerned, several basic decisions must be made. It should be noted that these decisions may have already been made by the standards set up in any given State, or by topographical features.

The lagoon may be either the flow-through or the complete retention type. Both are in use in Wyoming, although the complete retention systems are used only where no defined drainage exists. The complete retention systems are difficult to design since an exact balance must exist between precipitation and sewage flow on one hand and percolation and evaporation on the other. Although a number of engineers have tried to design these ponds, only a very few have achieved the nice balance necessary due to variations in precipitation and percolation. The current method is to design a complete retention pond as well as possible and enlarge it as experience dictates.

Since most sewage lagoons are of the flow-through type the remainder of this discussion will deal only with that type.

The flow-through lagoon itself may be of one of these types: (*a*) the "Raw Sewage Lagoon" which receives waste with no pretreatment; (*b*) the "Secondary Lagoon" which receives sewage which has been previously treated by sedimentation; and (*c*) the "Tertiary Lagoon" which is used to stabilize the oxygen demand due to nitrification of sewage after conventional secondary treatment and to further reduce the bacterial population.

The "Raw Sewage Lagoons" are the preponderant type in municipal systems in Wyoming. This has been due to the low cost of land and its ready availability over almost all of the State. In those few cases where conventional secondary plants have been built by municipalities, the land costs or location prohibited the use of ponds as a method of complete treatment.

The "Secondary Lagoon" is in use in several very small Wyoming municipalities following a septic or an Imhoff tank, and is often used in trailer courts following a septic tank.

The "Tertiary Lagoons" are very few in number and their use has more or less come about by accident rather than design. In the original state these ponds were emergency works with only a few days retention designed to protect streams from the effect of raw sewage discharges in the event of conventional plant failure. Their existence, then, has led to their use as a "Polishing Pond" which stabilizes nitrogenous demands and gives a further bacterial reduction in the final effluent.

Design Factors

The design of oxidation ponds has grown from a mass of observed data. We have felt for some time, that a rationale is called for to enable those in the

[1]Presented at a recent joint meeting of the Rocky Mt. Assoc. of Milk and Food Sanitarians, the Sanitation Section of the Western Branch of the American Public Health Assoc., and the Colorado Association of Sanitarians, May 24-26, Denver, Colorado.

field to design ponds for specific installations requiring a given degree of treatment. At present, in our opinion, the great majority of the ponds may easily have been overdesigned due to the lack of such a rationale. At present we are attempting to develop a method of design for these units.

Basically, there is nothing really new about the mechanics of an oxidation pond. In general, we believe that the ponds, within the limit of minimum amount of light, can be designed following the principles shown by Phelps and others. By over-simplifying the reasoning, somewhat, we might for purposes of discussion make the following assumptions: (*a*) all BOD is soluble; (*b*) all nitrogen is consumed by algae; (*c*) an excess of oxygen is present at all times; and (*d*) the minimum light or solar energy required is available. The mechanics, then, can easily be expressed by the integration of the equation $\frac{L}{L} = e^{-kt}$ which is nothing more than a standard BOD remaining equation. The solution of this equation for various periods of retention will give values having reasonable agreement with data observed in comparable cases.

This simplification leads to a number of interesting conclusions:

1. It should be possible to design a pond for a specific degree of treatment.
2. A retention period exists beyond which further retention has no obvious effect.
3. An optimum retention period exists for any case if this is to be considered a method of secondary treatment.
4. Standards should not be the same in all places, but should deflect the variation of the rate constant with temperature and various other factors.

Since the bacterial die-off curve is also proximated by the same type of mathematical expression, the same type of reasoning can be followed in that investigation.

Operational Factors

The actual case is not quite as simple as that which has been discussed. Problems are encountered in benthal decomposition since normal sewage does contain settleable solids which exert BOD. Anaerobic decomposition may occur, and heterogenous reactions seem to occur under certain conditions of ice cover; all of which destroys many of the simplifying assumptions.

It should be pointed out that Wyoming feels that this rationale is sufficiently promising to allow two to three times the population load per acre of lagoon surface area if sedimentation is used ahead of the lagoon. To date, lagoon operation has borne this assumption out, and in one particular case, the unsuspected presence of an unusual waste in a raw sewage lagoon has shown the effect of undesired sedimentation accompanied by the following benthal decomposition.

The existing standards used in Wyoming allow a BOD loading of 35 pounds per acre. It is generally believed that this load may be increased to around 50 pounds per acre in the more southerly states. This would be in accordance with the theory previously mentioned.

Insofar as shape is concerned, it is felt that a rectangular shape with no shore line irregularities is best. Inlet should be located near the center to assure complete dispersion of solids. It should be pointed out that some recognition might well be given to altered inlet location in small ponds (less than 10 acres) in areas with high wind velocity from a given prevailing direction.

The outlet from a pond should only remove water from well below the surface to prevent the skimming off of algae. It has been noted that ponds with surface outlets tend to give much greater difficulty than those with subsurface discharges.

The location of the outlet should be at the point most distant from the inlet. Although no evidence of short circuiting has been found in larger ponds exposed to the sweep of the wind, it is felt that this may occur in smaller ponds with strong prevailing wind. It would therefore seem that the strength and direction of winds may well require some adjustment of the outlet location in smaller ponds.

The pond should be constructed to operate at a minimum depth of 2½ to 3 feet to keep down the growth of rooted aquatic weeds which would encourage both the formation of sludge mats and mosquito propagation. The maximum depth of a pond should be approximately 5 feet. This will allow at least 2 feet of storage even under heavy ice conditions in cold areas or would allow a more favorable temperature condition in the pond in extremely warm areas.

Another item that should be mentioned is that of pond sealing. Although the type of soil is often adaptable to the use of lagoons, some soils require treatment to prevent excessive percolation which would lead to the exposure of solids.

Three methods have been used in Wyoming: (*a*) the application of a 4-inch clay blanket; (*b*) the application of an MC-Oil at approximately 0.5 gallon per square yard; and (*c*) the use of bentonite mixed into the upper few inches of the pond bottom. Each has proved satisfactory and choice is a question of economics.

It should be pointed out that the seal is only necessary for the first months of operation. After that period the dispersed solids and algae will effectively plug soil interstices.

Since practically all the States have criteria for this type of treatment, there is little need for more specific discussion of standards than that which has just been made. It would seem to be more valuable to point out a few favorable and unfavorable results that have come to the writer's attention.

In general it has been shown that oxidation ponds in Wyoming give a degree of treatment comparable to that achieved by any conventional method of secondary treatment. It has been our experience that BOD removal may vary from a low of 75% during winter months to an average of 95% during summer months. Bacteriological reduction is usually somewhat better than 90% with warm weather values approaching zero MPN values.

We have had our share of difficulties in addition to our successes. Fortunately these difficulties are few and practically all can be listed as follows:

1. A pond wall failed structurally and allowed approximately one acre foot of stabilized water to flow down on a small residential area. The failure was investigated and found to be due to poor construction practices around the outlet structure.
2. The biota in a pond was completely wiped out and septic conditions prevailed. The pond did not restore itself to operating conditions as expected. Investigation found that an oil line under the pond had ruptured and was leaking toxic hydrocarbons into the pond. The pond rapidly became operational after this was corrected.
3. The pond became septic, large accumulation of floating solids were observed and the water was a deep red. Investigation showed that a slaughter house with no pretreatment had been tied into the sewerage by the town. One interesting factor was that anaerobic conditions prevailed only from approximately 8 p.m. to 8 a.m. under a loading of approximately 100 pounds of BOD per acre.
4. One of two parallel cells in an oxidation pond became anaerobic and was characterized by deep red color while the other cell was aerobic and showed the usual green color. The water in the affected cell was found to have a high sulphur content, probably due to sulphur spring infiltration.
5. A large installation was found to have 2 aerobic and 2 anaerobic cells. Investigation showed that the loading had been equalized on the basis of an equal load to each pond, rather than equal loading per acre of pond surface. This has now been corrected and flow measuring devices are now required at all multiple cell ponds.

It is hoped that this discussion may serve as a simple introduction to sewage lagoons or oxidation ponds. In summary the following points are reiterated:

1. The sewage lagoon is not a magic tool to solve all sewage treatment problems.
2. Well designed ponds in correctly chosen situations will give sewage treatment efficiencies comparable to those of any other method of treatment and often at a fraction of the cost.
3. Operational difficulties have occurred due to misunderstood or ignored factors. A really good design of an oxidation pond takes quite a bit of thought, althought the results are certainly worth while.