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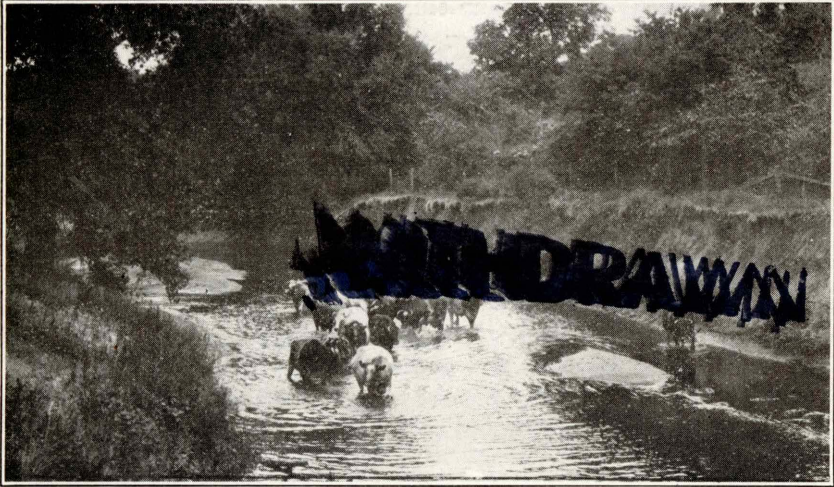
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OBJECTIVES IN SEWAGE TREATMENT

By JACK J. HINMAN, JR.

Presented at the Sixth Conference on Sewage Treatment  
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CONFERENCES on sewage treatment are held annually at Iowa State College, under the auspices of the Engineering Extension Department. These meetings are of a practical nature and are arranged for municipal officials and all others directly or indirectly responsible for the operation of sewage-treatment plants.

This publication is one of the more general papers which were presented at the 1924 conference. Several others from this meeting are to be published. In addition to the more formal papers, considerable time on the program was devoted to the consideration of sewage-treatment plant construction and operation, as well as to the individual problems of those in attendance.

## OBJECTIVES IN SEWAGE TREATMENT

By JACK J. HINMAN, JR.

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There are two general objectives in sewage treatment. One has to do with the actual improvement to a desired point of the physical, chemical and bacterial state of the waste-bearing liquids discharged into a stream, while the other is a legal objective having to do with the avoidance of damage suits, injunctions, and similar impediments to the use of the body of water for the purposes of the individual, corporation or community in question. To a certain extent these two objectives are related. That is, in order that the legal objective may be gained, a certain, more loosely-defined and generally less definitely-understood objective is established for the quality of the effluent from the sewer. The quality of effluent usually desired is that quality, and unfortunately often just that quality, which will be sufficient to avoid trouble with farmers, communities and others interested in the condition of the stream below the point of entrance of the sewage.

The community that has installed a sewage-treatment plant on its own community initiative, without urging through official and legal channels, is a most unusual community; and an industry that has, without official and legal urging, put in a treatment plant for improving its wastes (unless it saw that it could make some money by so doing) is a most unusual industry. Community and industrial altruism cannot be relied upon unless it is cheaper to be altruistic. This is not to be considered at all surprising, because effective sewage-treatment plants are only to be secured at a price of installation and upkeep that makes them a serious demand on the city or industrial treasury. But damage suits, legal battles, and injunction suits can be just as expensive or more; and so, given sufficient legal pressure, the plants are usually built. In some cases the mere possession and more-or-less effective operation of the plant is satisfactory to the people down stream. Frequently they have just as strong, though unsupported, confidence in the operation of the plant as the proprietors of the installation.

In cases where the burden imposed on the stream is heavy, or where those farther down have definite ideas as to what should be accomplished, and then proceed to satisfy themselves that the effluent measures up to the requirements, the objective of satisfactory plant operation may receive a much more definite meaning than otherwise. In order to ascertain what may be reasonable demands upon a plant and a reasonable sort of objective to be striven towards, it is worth while to ask what causes the trouble and why this trouble comes about.



### Objections to Water Pollution

Most of the objections to the addition of wastes to streams and bodies of water may be ascribed to one or more of the following situations:

1. First and foremost, the nuisance of objectionable odors arising from the stream and commonly associated with the decomposition of sulphur-containing organic matters.
2. The possibility of contamination of water supplies, or of putting too great a burden upon water-purification apparatus.
3. The possibility of the stream being rendered more dangerous as a source of water supply for cattle and other domestic animals.
4. The killing of fish and the interference with the safe and pleasant use of the stream for swimming and boating.
5. Various poorly-defined health hazards.

#### Objectionable Odors

The objectionable odors that arise from decomposing matters of any sort are so insistently brought to the attention of persons in their vicinity that they have probably been responsible for more sewage-treatment projects than any of the other objectionable characteristics of sewage accumulations. Odors are phenomena which do not require the services of the expert to detect. Any one with a normal sense of smell can tell whether an odor is being given off by the effluent from a sewage plant or from the stream into which wastes have been poured. But all persons do not agree as to what constitutes an offensive odor, or as to the point at which an odor just ceases to be objectionable.

It is the usual experience that liquids which contain sufficient oxygen for their complete decomposition pass through that decomposition with much less offensive evolution of odors than those liquids in which the oxygen is deficient in amount. In general, there are two ways of providing an ample amount of oxygen. One way is to limit the amount of sewage to a small percentage of the stream flow, trusting to the oxygen coming down with the water of the stream to provide for the decomposition of the sewage. The other way is to remove as much of the solid material as possible from the sewage, so that it may not accumulate in banks of sludge, poor in oxygen, from which foul odors arise. Then the liquids of the sewage should be put through some sort of equipment which is designed to hurry up the oxidation of the organic matter and to provide the amount of oxygen necessary for the work. The separated sludge is digested or rotted in special basins, while the effluent from the treatment of the sewage liquids is run away to the stream, having had a large part of its necessary oxidation effected,

and bearing with it some additional dissolved oxygen. The first one of these processes is the well-known dilution process, while the process described with more detail is the outline of almost any of the systems of sewage treatment.

Along with the production of foul odors usually go objectionable scums, sludge banks, and blackening of the liquid or of the stream. Each of these may be considered a part of the same process of decomposition. As a rule, whatever will avoid the bad smells will get rid of the objectionable appearances; but it is the odor that is most objected to.

#### Contamination of Water Supplies

Danger to water-purification plants exists wherever a water-supply is taken from a sewage-polluted stream. It is probable, so long as the concentration of the sewage is not too great and the water-purification equipment works as it should, that there is little danger. But water-purification plants do not always work perfectly, and we do not know with exactness what constitutes an unreasonable load upon the purification devices. We do know that the farther upstream the source of contamination, the less the danger, since the dangerous bacteria tend to die off in competition with the natural bacterial inhabitants of the stream. We are convinced that the less the amount of sewage, the less the number of these pathogenic bacteria and the less the possibility that some of them, passing down the stream, may get by the artificial barriers of our purification devices. But no stream is safe to use for drinking purposes unless it brings water from uninhabited regions where there is no possibility of human contamination, either by hunters or campers, or by more permanent population. Certainly no stream water in Iowa is safe to use in the untreated state.

In the past it has been thought more satisfactory to throw the burden of final purification of the water on the water plant than to hold the sewage plant responsible for the production of a safe drinking water from the wastes which come from the sewers in concentrated form. The most that we have a moral right to demand from the operation of a sewage-treatment plant is that it shall leave the water of the stream no worse than it was above the outfall. Then, if we are not satisfied with the water of the stream, we must begin our purification program nearer the source and clean up the stream as we go down. In this way we may raise the standard of quality which we may reasonably demand of any treatment plant until the stream is brought within the necessary or desired range of purity. It is foolish to ask that the effluent of the sewage-treatment plant shall be treated to such a degree of refinement that it might be said that the effluent was polluted by the stream water. Moreover, although it is possible to secure such a degree of purity, it is ex-



pensive both as regards cost of equipment and as regards operation charges.

Some years ago, the International Joint Commission on Boundary Waters asked some well-known experts to give them a standard by which to judge whether or not a water was so polluted that a water-purification plant could not be expected to handle it satisfactorily at all times. The standard prepared by the experts demanded that the proposed raw water should not contain organisms of the *Bacterium coli* group in more than 50% of the 0.1 c.c. samples of untreated water examined. There are plants, however, which are regularly operating on raw waters worse than the standard would allow and yet are giving acceptable results. In general, however, the treatment in these water plants is supervised by experienced men who are aided in their work by close laboratory control of the plant. We have some water plants in Iowa which are so operated; but the small plant is usually unable to secure this type of supervision. Moreover, the equipment of the small installation is sometimes for from as complete and as well thought out as it should be.

Thus the greatest danger from heavily-polluted water is met in the small plants when they are so located that they must handle highly-contaminated raw water. Thus, while sewage treatment is advantageous in any case, the treatment of sewage becomes more imperative when a water-treatment plant of the small, less-accurately-operated type is down stream. At the present time small water-purification plants in Iowa derive their waters chiefly from the impounded run-off of agricultural lands, but unless the writer is mistaken, the future will see a number of small water-purification plants installed of necessity on some Iowa streams that even now receive sewage and town drainage. Even though there be sewage-treatment plants provided, their work will be rougher in its nature than that of the water purification; and the treatment of the water will be the final safe-guard against infection. It is in the water-purification plant that the removal and destruction of bacteria of all sorts is most satisfactorily accomplished.

### **Bacteria in Sewage Treatment**

Many people think of a sewage-treatment plant as being primarily for the purpose of killing bacteria. It certainly is true that in the operation of a well-conducted sewage plant the bacteria in the effluent will be found much lower in number than in the raw sewage; but at some intermediate stage in the treatment the bacteria will frequently be found in larger numbers than in the raw sewage.

The sewage-treatment plant may be thought of as providing a sort of bacterial banquet. All sorts of bacteria come, and those that are able to do so, gorge themselves and multiply abundantly. After a time the food is nearly consumed, then the bacterial revelers die

off due to the unfavorable effect of a diminishing food supply, aided, perhaps, by the accumulation of toxic wastes. Sewage-treatment plants are primarily destroyers of bacterial food, in that they foster the temporary growth of bacteria that eat the food. Then, by the destruction of the food, they limit somewhat the numbers of the bacteria that survive the process. Sedimentation and absorption mechanically remove many of the organisms. Certainly the delicate pathogenic organisms that are so dependent on just the right sort of food and just the right temperature may be expected to be the heaviest sufferers in the scramble for food that follows the bacterial Saturnalia.

The conversion of the organic matter in the sewage, by the agency of the bacteria and related organisms, changes part of it into a form usable by the green algae. If the effluent is allowed to collect into ponds, or still bodies of water, it may be covered in a short space of time by a mantle of these green plant forms, or scums. In their normal growth these plants give off oxygen, which is a useful thing, for the oxygen helps out further decomposition and provides for the needs of fish. Unfortunately, some of the green algae, such as *oscillatoria*, have odors of their own which may prove objectionable to those who live in the vicinity. In this way a sewage effluent which is perfectly stable may cause a nuisance to occur.

Draining the effluent away to a stream will prevent difficulties of this type, as scattering the growth of the algae down the stream will reduce any odors to negligible amounts. Copper sulphate may also be used to kill off the algae. It should be used as early as possible after the first appearance of the algae, so that a large volume of dead and decaying vegetation will not be left. Ordinarily, a very small dosage of the copper-sulphate crystals is all that is needed; but there are some forms of algae that will survive any reasonable dose. Fish are sensitive to copper and the sensitiveness differs with the species; care must be taken not to add enough copper sulphate to kill the sort of fish that exist in the stream. Algae are often troublesome in water-works reservoirs, because of the odors and tastes that they impart to the stored water. They are combated in water-works reservoirs with copper sulphate, and aeration is sometimes resorted to in order to dissipate the odors.

Substances present in the sewage may themselves possess powerful taste-producing properties, either as they come from the sewers or after combination with some such substance as chlorine, which is so frequently used in modern methods of water treatment. Compounds of the latter sort are the phenols related to carbolic acid, or to phenols which come from gashouse wastes and from the decomposition of certain organic substances. When treated with chlorine, these phenols form substitution products, called chlorphenols, which can produce objectionable medicine-like tastes in astonishing dilutions.



### Pollution of Drinking Water for Animals

Cattle are commonly allowed to drink surface waters from brooks and ponds. Whether this practice is very often followed by ill results, I am unable to say. I should think it might be. Some diseased conditions may be transmitted to animals from man, of course. I imagine that the transmission of animal diseases and animal parasites from one animal to another through the medium of water may be very common. The animals stand in the stream or pond, and their droppings may contaminate the water which is afterwards to be taken as drink by other animals. The contaminated water may contain pathogenic bacteria, as well as the eggs or larvae of animal parasites of the intestinal tract.

One can even imagine the transmission of infections and infesting organisms through the medium of the common drinking trough. Saliva and nasal discharges from diseased animals mixing with the water might bring about an attack of the disease on another animal—but I never heard of any such slogan as, "Individual buckets for contented cows." Perhaps they are things of the future. It is true that somewhat similar devices are supplied to cattle in the very elaborate barns of model dairies, and such things as individual pails are not more fantastic than our ideas about individual drinking cups would have been thought a few decades ago.

Seriously, however, the matter of a proper sort of drinking water for animals is worth careful consideration. Certainly the best water for animals is water that would be accepted as entirely suited for human consumption. The animals do not get that kind of water from surface ponds and brooks. I should like to learn something really definite about this subject from some worker in the field of veterinary medicine who had studied the matter of water supply for domestic animals as the matter has been studied in the case of water supplied to the population of cities.

Time after time samples of stream water—usually stream water that has received sewage pollution—are sent to the Water Laboratory Division of the Laboratories for the Iowa State Board of Health, and we are asked to say whether or not the sample of water is safe for the use of cattle. Usually the owner of the cattle is concerned about the matter. Sometimes he says that his cattle are not doing well, or that he has lost one or more head of stock. The matter has not been studied as an epidemiological study of an outbreak of typhoid fever is studied. All that is available is a mass of opinion from which it is hard to sift out the facts. The owner is worried and has vague notions about mysterious poisons in the sewage or sewage-treatment plant effluent.

I am not as much impressed by the mysterious poison as I am impressed by the fact that it is possible for disease to be transmitted to the animal from human or animal sources. The causative agents

of these disorders are pathogenic bacteria, eggs and larvae of worms, flukes and other organisms that are parasitic, filterable viruses, and possibly other matters as well. It is difficult to feel sure in one's own mind as to the point where a water becomes unfit for animals. We have been holding that a water becomes unfit for cattle at that point where it is possible to note a definite difference between a normal stream water of the region and the water under examination. However, it is not always easy to say just what is characteristic of a normal stream water of the particular region; and we are not certain that the criterion thus tentatively established may not sometimes be too lenient, and at other times too strict.

The farmer is justified, of course, in demanding that his cattle shall not be endangered by water flowing onto and through his land, but has he not the right also to demand a certain factor of safety in the quality of the water? It would be decidedly advantageous to know how to come reasonably close to an appreciation of what is necessary. The town has a right to legal protection if its sewage-treatment plant is giving ample sanitary protection, and the farmer also has his right to be assured of the protection of his live stock.

In Iowa, where a number of towns of considerable size (such as Newton and Grinnell) are forced by their location to discharge all of the town sewage into small creeks which flow for some distance across agricultural land before receiving dilution in a stream of size, the matter of protecting cattle is very important. Such streams as these towns use are nearly dry in summer; adequate dilution is not possible.

A riparian owner is generally considered to have the right to have a stream flow through or past his land with its quality unimpaired and its quantity undiminished, except in such manner and to such extent as may result from a reasonable use by the proprietors of the land above him. It has generally been considered that the riparian owner had no recourse for incidental contamination of a stream by the cattle belonging to an owner for up stream, unless such herd was so large that the wastes were very considerable in amount. Recent experiments by Dr. Schroeder, of the Government experiment station at Bethesda, Maryland, have shown that bovine tuberculosis could be transmitted from a herd of infected cattle, pastured in a field on a stream, to a herd of tuberculosis-free cattle, kept in a lower pasture several hundred yards away and out of sight of the first field. This fact may later give the courts a chance to determine if the reasonable use of a field includes the pasturing of tuberculosis cattle or cattle which have not been found to be free from bovine tuberculosis; but it has been held that pasturing cattle, even above a water supply for a city, constitutes a reasonable use.



### Stream Pollution Versus Recreation

Just now there is a great deal of useful propaganda being put out on the subject of stream protection by the sportsmen's organizations. They are in favor of cleaning up our streams, with the idea of returning them, as is said, to the condition in which the first pioneers found them. The sportsmen's organizations are primarily interested in the fishing, boating and swimming in the natural bodies of water, and in securing safe, pleasant and beautiful places for recreation. But they are not blind to the other advantages of the program they are forwarding. Their chief interest, however, lies in preserving, or restoring, if need be, the heritage of the children in the America of the outdoors.

The economics of the situation is hard to measure, and it ought not to be taken too much into account. The fish which are taken from a small stream are probably not often worth as food supply what it would cost the state and government to propagate and distribute the young fish, or what it would cost city, state and industrial agencies to keep the contamination of the stream within reasonable limits at all times. The protection of the "old swimmin' hole" below the city sewers would probably cost enough to provide each boy who wishes to use it with a ticket to an elaborate natorium and leave enough, over and above the expense, to make a fairly reasonable sum. To be sure, it has been decided that the use of the stream for dumping city sewage, aside from storm water run-off, may not be a reasonable use of a stream. The same has been held to be the case with industrial wastes. It would seem that the riparian owner could interpose objection to the stream pollution under his common-law rights and could insist upon the protection of the stream sufficient to allow fish to live and multiply in it. In spite of the fact that swimmers run certain risks of infection when bathing in sewage-laden waters, it might be hard for a riparian owner to obtain relief from this danger. It would depend upon what would be considered a reasonable use.

The writer, for one, is willing to subscribe to the doctrine that the community owes it to its citizens—and especially to its future citizens—to preserve the beautiful natural bodies of water and to keep them in such condition that they may be freely, safely and joyously used for recreation.

### Other Hazards of Water Pollution

By ill-defined health hazards, in the list given above, are meant the sorts of health hazards that are often talked about quite glibly, but with a very hazy idea about what they really are or why the water of the stream is to be blamed for the condition. The most plausible of these health hazards are based on the breeding of flies and the carrying of infectious material to food by the agency of

the flies; the infection of fish by parasites, such as various Asiatic flukes, which might cause disease in man were the fish eaten raw; contamination of milk from the soiling of bodies of cattle that had stood in a polluted stream; and the occasional contamination of wells by the overflowing of polluted water during floods. Possibly the nausea associated with the irritating psychical effect of odors should be included here, but the odors themselves are a nuisance.

None of these is of the same degree of importance, as a disease-causing matter, as is the contamination of public water-supplies or of water-supplies for animals, or the danger of typhoid and similar diseases caused by bathing in water containing fresh sewage.

It has been noted, however, that the thing which causes the most public indignation and which has resulted in the construction of the largest number of purification plants for sewage and industrial wastes, is not, strictly speaking, a health matter at all. It is the nuisance of the objectionable odors of decomposition.

As knowledge in the matter of waste disposal becomes more widely diffused this matter of the nuisance of odors will probably be less responsible for new construction. This will not be because the public will object less to the odors of decomposition. They will object more. They will, however, already have secured relief from much of this annoyance, and will be interested more in the adequacy of the protection afforded by the equipment. Just now, if a sewage-disposal plant exists, it is probably giving results satisfactory to the town (provided there is no water-supply plant taking water from the stream), if odors are avoided and enough dissolved oxygen is in the effluent so that fish in the stream receiving the discharge are apparently not affected.

### Better Plant Operation Needed

More rigid demands upon the operation of sewage-treatment plants are certainly in prospect. Not much longer will the haphazard operation of small sewage plants be tolerated. The demands of the public are steadily growing more and more definite and, if the objective of avoiding legal controversy is the one which appeals to those in responsible charge of the affairs of a community, then adequate methods of disposal of wastes of all sorts will need to be installed and operated in an efficient manner.

Purification of community and industrial wastes must eventually be undertaken in almost all communities. Rational handling of the equipment must then follow.



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