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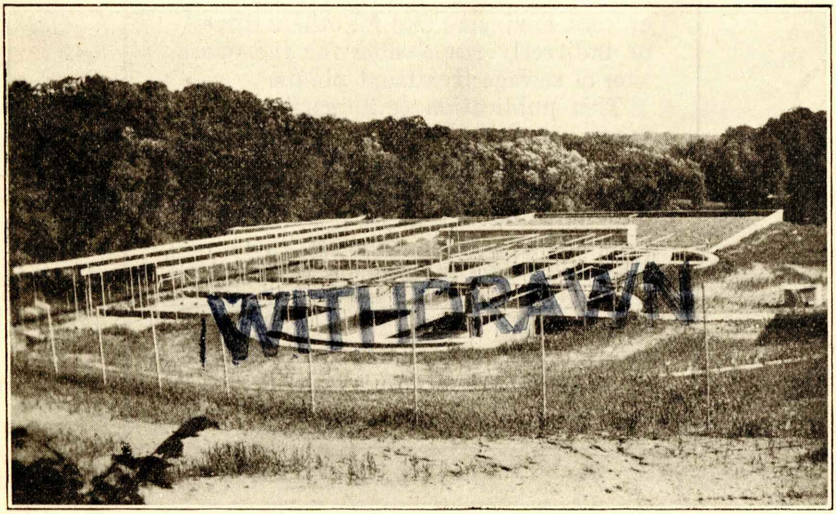
SEWAGE TREATMENT PLANT PROBLEMS

Papers Presented at the Ninth Conference on Sewage Treatment at Ames, Iowa, November 8, 9, and 10, 1927.



Bulletin 96

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

This publication contains five of the more general papers which were presented at the 1927 Conference. The balance of the program consisted of practical talks on treatment plant construction and operation, demonstrations and discussions of the problems encountered in the care and operation of such plants. Considerable time was devoted to the consideration of the individual problems of those in attendance.

CONTENTS

The Upkeep of Plants and Grounds

By C. H. Currie

President, Currie Engineering Company, Webster City, Iowa

The biggest factor in successful sewage treatment, and at the same time the one most neglected, is the upkeep of sewage treatment plants. Too often the sewage treatment plant is located in such a place that when poorly operated it does not notify people by its odors that it needs care. Slight neglect develops into total neglect, and the plant goes to pieces. Eventually, it sends out a loud enough odor call so that the cry is heard, and people wonder what is the matter with the sewage treatment plant and with the engineer who designed it. Every engineer who has designed sewage treatment plants knows this to be the case. This, in fact, is the main reason for the existence of the conference on sewage treatment which the College here at Ames has held each year for eight years. Some of the blame for this neglect should be placed at the door of the engineer who designed the plant. Had he located the plant as close to town as possible, had he seen that the superstructure was architecturally pleasing, had he seen that good landscaping was performed around the plant to make it look attractive, he might have been able to impress the people with the importance not only of protecting a big investment, but also of looking after it for the sake of appearance and successful operation.

A sewage treatment plant can be constructed so attractive architecturally, and the grounds laid out and planted so well from a landscape point of view, that it will become one of the show spots of the community. While this might easily be carried to the extreme and an unnecessary amount of public money wasted in so doing, engineers have in the past been leaning too far the other way. Many sewage treatment plants in total disuse in Iowa today are proofs of this fact.

Upon being called into a town some time ago to tell what was the matter with the municipal sewage treatment plant, it was found that the weeds on the sand filter bed, were at least five or six feet high; the hinges and locks on the door of the building covering the tank were rusted so badly that the door could not be opened; some of the glass in the windows was broken out. There were no tools. The gasoline engine apparently had never been oiled and protected from rust—and the city officials wondered what was the matter with their plant! The plant was located near the city dump with no trees or shrubbery of any kind around it. The building was not architecturally attractive. Perhaps they would have neglected it in any event, but it is possible and even probable that had a few thousand dollars additional been expended in improving the appearance of the plant and grounds they would have had sufficient pride to have taken care of the plant and thus prevented its getting into such bad condition.

The plant operator who will keep the grass and weeds down around his plant at all times, keep his sand or stone beds clean, take care of the settling tank in the way that it should be taken care of, (as several of the operators here present are doing with their plants), he will have something of which he and the citizens of his community will be proud, rather than a disreputable plant with which they will all be ashamed and disgusted.

I think I can say without danger of contradiction that the plants operated by the men who have been attending these conferences are, on the whole, successfully operated sewage treatment plants, and are by all odds the best operated plants in the State of Iowa today. No sewage treatment plant can be designed and constructed that will operate successfully without proper attention, and the operator is, therefore, just as important in the successful handling of our sewage problems in Iowa as is the designing engineer.

Shrubbery banked in corners and other advantageous spots around the buildings of your sewage treatment works will add greatly to the appearance of your plant. Suitable shrubs can generally be secured locally. A beautiful grass can always be grown at any sewage treatment plant, because of the available sludge for fertilizer. City water, if available, is a great aid in keeping things clean, and should be provided at every sewage treatment plant.

If every operator, city official, and engineer present will see to it that his plant and its surroundings are kept in neat condition during the next year, the general results in the increased interest and consideration of the public will be surprising, and can be made the subject of a very interesting paper to be given before the next conference.

Some Sewage Purification Problems in Iowa

By Max Levine

Bacteriologist, Engineering Experiment Station, Iowa State College, Ames, Iowa

These annual sewage conferences together with the work on creamery wastes for the Engineering Experiment Station, have served to keep the problem of waste disposal in a prominent position in our thoughts.

In the course of the past few years, the writer had occasion to visit a number of sewage disposal plants in Iowa, and as a result of these visits, he cannot help but feel that sewage purification in Iowa is not, as a rule, very efficiently controlled. There is probably no city in Iowa which could supply information, on demand, as to the degree of purification effected by its disposal plant. We are thus put in the ridiculous position of building an expensive plant to purify our wastes and then making no attempt whatsoever to ascertain whether the disposal plant is accomplishing its purpose. This inconsistency is due, in part, to the lax attitude generally assumed towards sewage purification by municipalities, but to a great extent must be charged up against those engineers, who are not sufficiently interested in their own designs to find out how adequate or inadequate they are.

This brings us to the problem of the relation of the consulting sanitary engineer to the municipality. What kind of service should be expected of such a consultant? Should he be expected to make a careful study of the local situation, (including the biological and chemical, as well as the engineering aspects) as a basis for his design, or are we to anticipate merely an expansion or contraction of a plant which is supposedly successful elsewhere? All of us would probably indorse the first alternative, yet one cannot help but feel that, until a few years ago, the second procedure was by far the more common.

A small town, with only about sixty families contributing sewage, was induced to spend over $40,000 on a plant. The character of the water was such that the type of plant built was predestined to failure, and it has turned out a nuisance to the community, and a detriment to sanitary progress along the line of sewage treatment in that locality. Proper consideration and appraisal of the biochemical aspects would have averted this unfortunate situation. To avoid such calamities, thorough training of our forthcoming Sanitary and Municipal Engineers in bacteriology and chemistry cannot be too strongly stressed.

Another question which needs careful consideration is the relation of municipalities to their industries with respect to waste treatment. Are the towns to take care of all the sewage or are the industries to be required to purify their own wastes?

In connection with last year's sewage conference, a special session was devoted to this problem with regard to creamery wastes. Two diametrically opposed views were expressed. That of the municipal representatives was that industrial wastes should be entirely excluded from the municipal sewage, whereas the industries felt that as tax payers, they were entitled to the use of the tax built and tax supported plants. After considerable discussion, it was the concensus of opinion that the industry ought to be permitted to use the city sewers, provided its waste did not interfere with the municipal sewage disposal system. That is, if a creamery waste could be partially purified, it might then be added to the municipal sewage for further purification. With respect to creamery wastes, our Engineering Experiment Station has been carrying on investigations for several years, as a result of which some definite information of what might be done is now available. No sufficient evidence is at hand, however, concerning such wastes as canneries, beet sugar factories, packing houses, etc.

The problem as to how the necessary information is to be obtained is an important one. In the large industrial centers, it is the practice to have the industries investigate and solve their individual problems and it has been suggested that the same procedure might be required here.

The relatively small units, characteristic of Iowa industries, (packing houses, creameries, canneries, etc.) are not comparable with the much larger eastern industrial plants, with respect to financial assets: With very few exceptions, the cost of ascertaining the most suitable devices for treatment of its waste would be prohibitive for any one industrial plant. Some assistance from available state departments (as is being done by the Engineering Eperiment Station for creamery wastes) seems essential, if the work is to be done at all. The possibility of inducing an industry as a whole to interest itself in waste purification needs to be carefully considered.

Stream pollution is rapidly becoming a serious problem in some sections of Iowa. This question is closely associated with that of purification of industrial wastes. Practically no information is available as to the ability of our streams to consume the wastes which they receive. The consulting sanitary engineers are therefore lacking the necessary fundamental information upon which to base the degree of purification required. The State Board of Health has made a beginning in its observations on Lime Creek and Shell Rock River. More detailed studies on stream pollution are sorely needed, and the state sanitary authorities should be encouraged and supported in their efforts along these lines.

The Sewage Treatment Plant Operator's Job

By Ernest Boyce
Director and Chief Engineer, Kansas State
Board of Health, Lawrence, Kansas

The sewage treatment plant, regardless of whether it is a simple septic tank or an elaborate layout for the complete oxidation and disinfection of sewage, exists because of some definite need to modify the raw sewage before it can be accepted as a part of the surface waters of the state. Presumably any treatment plant installed is planned so as to carry the purification process to the point where the effluent will be acceptable. To do more than this is to incur unwarranted expense and to do less is to invite criticism and litigation.

We have suggested that the effluent should be acceptable. Briefly, it should be acceptable to anyone who has any public or private riparian claim to the surface waters that receive this effluent. Decision in this matter should not be a mere matter of whim but should be based definitely on the change that takes place in the usefulness of the surface waters as the result of the effluent it receives. It is right and proper that those charged with the responsibility of viewing these conditions from a health standpoint should set requirements for the quality of the effluent high enough to give a reasonable margin of safety from this standpoint. Further than this, our courts have repeatedly held that it is a proper function of government to preserve the aquatic life of the state and that any pollution that is destructive of fish life is an infringement of the rights of the public to use and enjoy the surface waters.

Unfortunately, the conditions that exist at the time a treatment plant is built are not constant and the variations that later develop not infrequently make it necessary to modify the plant. The change may be in the volume or strength of the sewage or it may be caused by increased requirements due to changed conditions along the receiving stream. Improved methods of sewage treatment make older installations as definitely obsolete as do the changes in automobile or other engineering design.

How then does this apply to the operator and his job? It is his job to operate the existing disposal works so as to secure the most satisfactory result possible with the type of plant under his charge. He is apt to feel that he is not producing anything having economic value when compared with the operation of other utilities but this we feel is a mistaken viewpoint. He is taking a volume of water spoiled for further use and by subjecting it to treatment in the plant is making it again useful. We have been prone to regard the sludge that is removed from the sewage rather than the purified water, as the product of the plant.

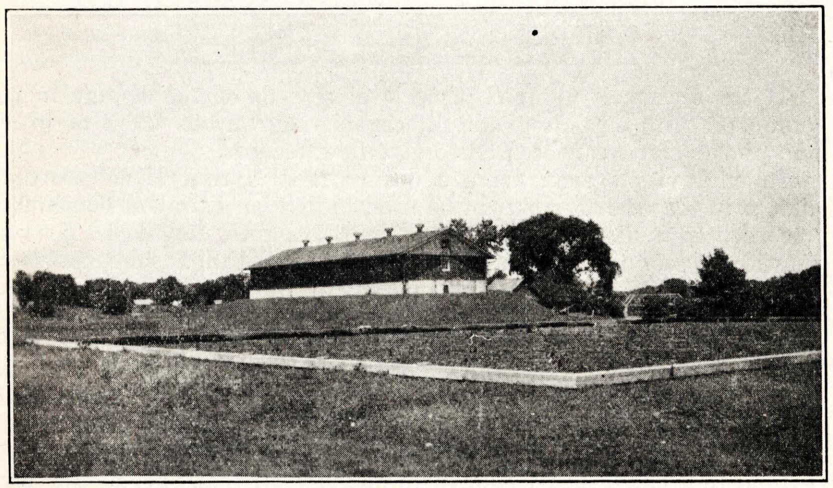
The operator should know at all times whether or not his plant is producing the best possible effluent for that type of plant. If conditions are such that a satisfactory effluent is not being produced part of the time, then he should know these conditions and further should have sufficient plant records to justify his failure to produce the desired results. A study of these records would then indicate the difficulties as well as the advantages of that particular installation and would suggest the limiting factors that should be improved in order to get a uniformly better effluent.

As suggested in the beginning, the degree of sewage treatment depends on several factors and the plant should be designed for the definite purpose of meeting the requirements imposed. These local conditions in one place may require a very highly purified effluent while in another place septic tank treatment alone may be all that is needed. In the one case, the operator's job is very technical and considerable skill is required to get the results. By proper equipment, he can modify operating conditions of the plant and thus control the quality of the effluent produced. In order to use this control wisely, he will need to resort to various plant tests and measurements. The records kept of these tests and measurements together with his recorded action based on the data thus obtained constitute what one might choose to call essential operating records.

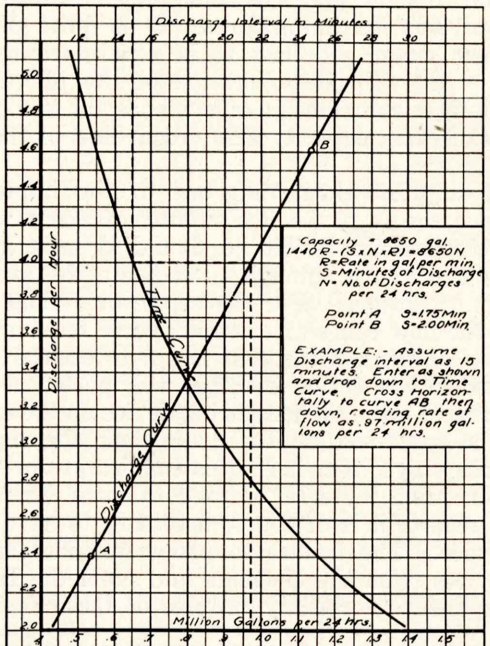
The man who operates a single compartment septic tank and hopes to get a clear effluent at all times is quite apt to have difficulties that the design of the plant does not permit him to avoid. If he has two or three compartments of varying size in his tank, he may be able to use another compartment if one gives trouble, and thus his plant becomes more flexible and his duties as an operator increase. It then becomes more important that he know the amount of sludge in the tanks as measured at regular intervals and to know when a compartment is failing to remove the settleable solids. He may even try to maintain a fixed rate of flow through the compartments or at least avoid excessive rates, and thus make use of records of flow; making such records as a part of his operating duties.

The various plant records and tests are either related directly to the problem of the operation of one individual plant or else they are being collected for comparative examination in a study of a group of plants. While the second purpose is important from the standpoint of research and design, for simplicity these records should not be confused with those necessary as a part of the operating data. Since the quantity of sewage flowing at all times is a very important factor in all treatment plants, it would seem that equipment for a continuous record of flow should be considered essential. Actually, this information is quite apt to be lacking. Suppose that a plant is designed to handle a given maximum flow and that it operates satisfactorily until from some source storm water runoff floods through the sewer. The operator is able to observe that something has happened but he is not in position to show that this something is unusual unless he has records of previous maximum flows. It is quite probable that the source of storm water will have to be eliminated by some one who has nothing to do with the operation of the plant. A continuous record of flow is a valuable bit of evidence for the operator to have when matters of plant capacity arise, regardless of the cause of variation in flow.

We would suggest, then, that one of the important duties of the plant operator is to keep a record of the sewage flow. If a continuous record is impossible he should at least make and record observed flow frequently enough to indicate the average, maximum and minimum variations. For the septic or Imhoff tank without a dosing tank, the flow can be measured over a rectangular "V" notch weir. Because of the settling that is apt to occur if a suitable stilling box is used in connection with the weir placed ahead of the tank, it is usually best to place the measuring device on the effluent line. The removal of the suspended solids in the tank also makes it easier to avoid their clogging. Further, it is important for accurate results that a non-corroding material be used to form the weir edges. For a continuous record, it is of course necessary to have a float actuated recording device. The failure to properly house and protect such recording devices from the elements and from the H_2S of the septic sewage is responsible for many failures of these devices. For inter-



TYPICAL IOWA SEWAGE TREATMENT PLANT, CHARLES CITY, IOWA mittent readings, a hook gage and suitable stilling well should be installed to measure the depth of flow over the weir. In case of limited head, it is possible to use the "V" notch weir for the low flows and to install a rectangular weir at one side to measure with the "V"



TYPICAL DISCHARGE CURVE
SEWAGE DISPOSAL PLANT
DOSING TANK DISCHARGE

If the sewage is pumped, time level records of the sewage in the pump pit with data as to the pit capacity at various levels at which the pumps start, can be used to give flow records.

In a gravity system using a dosing tank, a time level recording device in the dosing tank can be used to give an excellent continuous record. In a diagram accompanying this paper, Mr. J. L. Barron, Asst. Engineer of the Kansas State Board of Health, has demonstrated a method of correcting for the amount of inflow into the dosing tank during the period of the siphon discharge. To make use of this method of measuring flow, the capacity of the dosing chamber must first be accurately determined. Then by means of stopwatch measure notch weir the maximum flows. The crest of the rectangular weir in such an installation would be a fixed point at a definite height above the bottom of the "V" notch weir but the sides of the latter would extend to a height great enough to measure all that part of the maximum flow not passing over the rectangular weir.

ments the time of siphon discharge and the filling period are determined to establish a dosing cycle or discharge interval for low and high flows. With this interval and the time of siphon discharge (s) it is possible to determine the number of discharges (N) in 24 hours at this rate of flow. If the capacity of the tank is (C) gallons, then the rate (R) in gal, per m. can be determined from the formula 1440 R — (S x N x R) = CN. Since the rate of flow and the number of discharges per hour are directly proportional, two computations of R can be used to establish the straight line curve. Since the discharge interval or dosing cycle is observed or recorded, the use of the curve is facilitated by the construction of curve between the number of discharges per hour and the discharge-interval in minutes.

Having assumed that the operator has in some way determined the sewage flow and its variations, we may next consider that part of his job that has to do with sedimentation and sludge digestion processes. This part of the treatment again may be a simple septic tank with little chance for operating control or it may be a carefully planned separate sludge digestion tank complete with many appurtenances to make its operation flexible. With the septic tank there is little need for tests that indicate the conditions under which the sludge is digesting. While it might be of interest to know these conditions, the knowing of them will not enable the operator to change the working of his plant. Measurements of sludge and suspended solids in the effluent do indicate whether the septic tank is performing the function for which it was designed and such tests or measurements are important, and are recognized as being the proper ones to indicate when the tank should be cleaned. With the Imhoff or separate sludge digestion tank, some control of the sludge digestion part of the tank is possible. Since it has been demonstrated that temperature and hydrogen ion concentration are important factors in sludge digestion and since these types of digestors admit of at least some control, these tests are records which should be carried just as far as these factors can be controlled. While the temperatures of the air and incoming sewage are frequently recorded, we would suggest that the temperature at which the sludge is digesting is even more important. In the larger Imhoff plants, possibly, and certainly in the separate sludge digestion tanks we believe that the temperature is important enough to warrant the use of recording thermometers.

As to hydrogen ion control, colorometric methods have been perfected to a point where any operator can soon learn to observe the pH of the digesting sludge and since all bacterial action is quite sensitive to the variation that may occur in the range from acid to alkaline reaction, this test is a valuable one as an indicator of unusual conditions in the digester. Not only must the operator watch the digestion process closely and know as near as possible that the destruction of the organic matter is being accomplished but he must also plan the regular removal of the inert earthly residue or sludge. This removal should be accomplished with the minimum disturbance of the partially digested solids that occupy the upper and usually the larger part of the digestion compartment. The operator should make it a rule to draw a small amount of sludge frequently, instead of removing a large amount at one time. The latter method results in having more or less undigested sludge on the drying beds and a retarding of the normal action of the tank. Most sludge beds, if they are not already divided into small areas for frequent sludge removal can be so arranged by the use of posts and plank. Sludge levels should be checked and recorded frequently and depth samples taken to indicate the condition of the sludge before removal. There is no advantage in leaving large amounts of completely digested sludge in the tank provided drying conditions are good, and the space may be needed later when storage is necessary. Methods of determining sludge levels are varied and will not be discussed here. The operator will, however, find that the recording of the volumes of drained sludge as measured on the drying bed will, over a period of time, give him an excellent check on the volume of sludge that he may expect, and provided the digestion tank conditions are normal, at least a possible check on the measured sludge levels.

While some plants are so located that the removal and digestion of the settleable suspended matter is all that is required to make the effluent satisfactory, many, if not most, operators are in charge of plants where it is important that there be further treatment of the organic matter in the sewage after it leaves the settling tank.

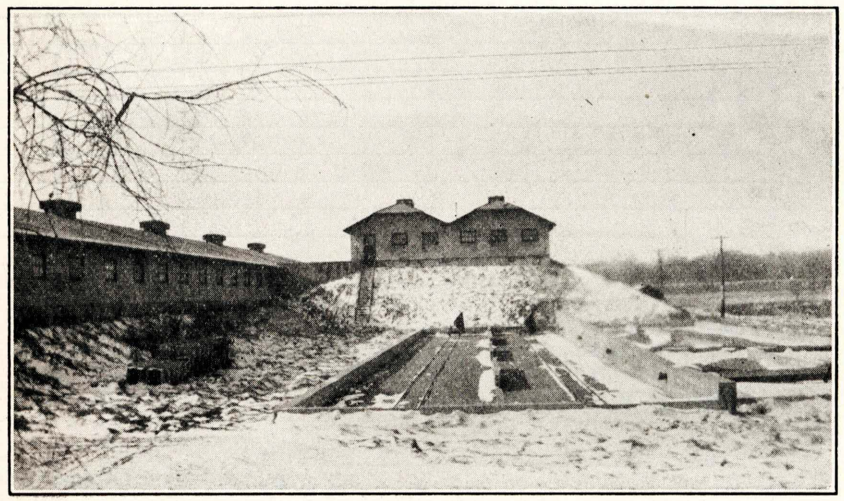
Regardless of the type of secondary treatment, all processes are for the oxidation of the organic matter either in nonsettleable suspension or in solution and the degree of success can be measured by the oxygen demand of the effluent. If an effluent is produced that is not putrescible or does not have an oxygen demand in excess of that which may be easily supplied by re-aeration, the purpose of these processes is being accomplished. Since the public is prone to judge the satisfactory operation of a treatment plant by the acceptability of the effluent, and quite properly so,—it follows that the operator should be informed at all times as to the effectiveness of the oxidation process. The methylene blue stability test has become quite standard for this determination and should be in more general use. It measures visually the effectiveness of the oxidizing process and has the advantage of simplicity. While erroneous results may be obtained, they are more apt to be the result of the collection of samples that are not representative rather than for any other cause. For example, the collection of an effluent sample in the early forenoon cannot be considered as representative of the effluent for the day. Many excellent stability results are obtained by the collection of effluent samples when the sewage going through the plant consists mainly of leakage and flush tank discharge. To have representative tests, it is obvious that these samples must be collected at various times of the day. With regular stability tests the operator knows that the product which his plant is producing is, or possibly is not, up to the required standard.

He is warned before the receiving stream becomes septic and being warned can take steps to correct the failure.

As yet, few plants are attempting to treat the sewage further than to change the organic matter so that the effluent will be non-putrescible. Bacterial purification is for the most part incidental, and in those plants where it is but incidental, it would seem unnecessary to consider bacteriological tests in the group of operating tests. These become operating tests, however, whenever we consider a plant that is designed to reduce the number of bacteria appearing in the effluent. There are those who feel that the use of germicidal chemicals for the sterilizing of otherwise satisfactory effluents should be more general. In answer to this, we would again suggest the thought expressed in the first part of this paper,—the usage of the surface water into which the effluent goes should determine the degree of treatment required.

Whatever the type of treatment,—whether it be simple or complex, it is important that adequate operation be provided. Failure to operate a treatment plant in the manner for which it was designed not only defeats the purpose for which the works were constructed but also is apt to create a sense of false security on the part of those on the receiving stream below.

The keeping of operating records will not necessarily insure good operation, but after the inspection of a good many plants, it has become very evident that as a rule good operation can be expected where records are kept. A careful operator is proud of the work that he is doing and is glad to record it and show the results. Unless one has this spirit, there is little hope that a treatment plant under his charge will ever give the results that should be expected.



SEWAGE TREATMENT PLANT, MASON CITY, IOWA, SHOWING SLUDGE BED, ENCLOSED IMHOFF TANKS, AND SPRINKLING FILTER

MONTHLY OPERATION REPORT OF SEWAGE DISPOSAL PLANT .... Iowa

19........

Day	Stream Condition	PLANT DATA				SEPTIC OR IMHOFF TANKS								SPRINKLING FILTERS						SAND FILTERS					
		Pumpage or Flow	Temp.		No. of Tanks in Use	Condition of Contents	Average Depth of Scum		Average Depth of Sludge	Settling Solids				Period of		Settling Solids Outlet		Stability		Turned On, Off, Cultivated, Cleaned				Stability	
			Air	Sewage			Gas Vent	Sed. Cham.		Inlet 1 hour	Inlet 2 hours	Outlet 1 hour	Outlet 2 hours	Contact	Rest	1 hour	2 hours	Dilution	Figure	Filter No. 1	2	3	4	Dilution	Figure
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
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26. Date of last scum treatment................... What was done?...................
27. Date of last removal of the sludge from tank...................
28. Depth of wet sludge on sludge bed...................
29. Depth of the same sludge when dry...................
30. Date of last removal of dry sludge from bed...................

General remarks: ....

Respectfully submitted,

....
(Name of municipality or company.)

By...................................
(Name of officer.)

SEE OTHER SIDE FOR DIRECTIONS FOR MAKING TESTS AND FILLING OUT REPORT

EXPLANATORY NOTES

SEWAGE TREATMENT PLANT RECORD SHEET

TESTS:

Samples of raw sewage and of the effluents of the various tanks, beds, etc., should be taken at least twice weekly, and tests for relative stability and settling solids run on these.

RELATIVE STABILITY:

Fill a 4-oz. bottle to overflowing, add 1 c.c. Methylene blue solution. Insert stopper and let stand at room temperature until the blue has faded out. Note the number of days to change the color, and record the stability figure.

A sewage may be called stable when the contained organic matter has taken such a form that it is not capable of undergoing offensive putrefaction.

Relative stability is the ratio of the available oxygen in the sample to the amount required to render it stable.

A stability figure of 75 means that the sample contains 75% of the oxygen necessary for stability.

The accompanying table gives the stability figures for different periods.

For effluents of extremly low stability dilutions should be made in aerated water and the relative stability of the mixture noted. A few trials will be necessary before the proper dilution may be determined.

Time Required to Decolorize Methylene Blue at Room Temperature. Days	Stability Figure
0.5	11
1.0	21
1.5	30
2.0	37
2.5	44
3.0	50
4.0	60
5.0	68
6.0	75
7.0	80
8.0	84
9.0	87
10.0	90
11.0	92
12.0	94
13.0	95
14.0	96
16.0	97
18.0	98
20.0	99

Settling solids: Place 1000 c.c. of sample in settling glass and allow it to remain quiet. Record c.c. of sediment in bottom of glass at the end of 1 hour, 2 hours, from time of filling the glass:

This test approximates the action in a settling tank, and a comparison of the effluent of a tank with a sample that has had a settling period in a glass of equal length to the detention period in the tank gives a good check on the operation of the tank.

WHAT TO RECORD

Column No.

1. Whether the stream is "flood," "low," "frozen," etc.

2. If sewage is pumped a record should be kept of the time pumps are in operation. If the sewage flows by gravity it may be possible to install a V notch weir and readings taken of the head on this weir. If there is a dosing tank for contact bed an automatic counter can be installed.

The Division of Water and Sewage, Board of Health, will gladly furnish assistance in installing one of these devices and make the necessary computations so that the work for the operator will be minimized.

3. Temperature of the air at the plant.

4. Temperature of the sewage at the plant.

5. If the plant consists of more than one Imhoff or Septic tank give the number that are in use.

6. Whether it is "foaming," "no action," "considerable action," etc.

7. Measure the depth of scum at different points in the gas vents and record the average of these figures.

8. Measure the depth of scum at different points in the sedimentation chamber and record the average figure.

9. Take samples at different depths by means of the "sludge sampler" and record the average depth of the sludge.

10, 11, 12, 13. Take a sample of sewage entering the tank and another sample after the sewage has passed through the tank and make the test for settling solids as described above.

14. A period of contact for a contact bed is the time after the filling of the bed is completed until the bed starts to discharge. The period of contact for a sprinkling filter is the time of spraying. In some plants this is continuous and in others intermittent.

15. Period of rest for a contact bed or sprinkling filter is the time between doses of sewage when the bed is standing idle.

16 and 17. Samples of sewage after passing through the contact bed or sprinkling filter should be taken and tested as directed above for settling solids.

18 and 19. Take another sample from the same place as for 23 and 24 and test as directed above for stability.

20, 21, 22, 23. Whenever a filter is turned off, on, cultivated, scraped or cleaned, it should be recorded in the proper place. Your filters should be numbered and these numbers used whenever referring to that particular filter.

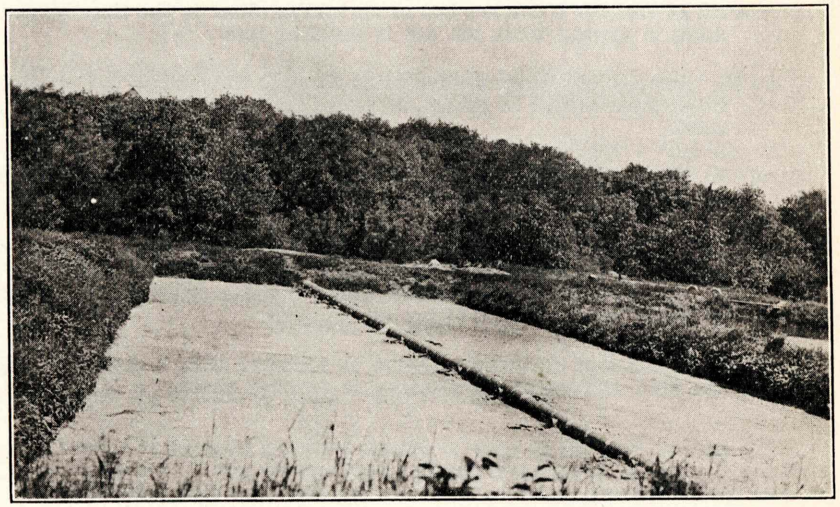
24 and 25. Samples of the sewage should be collected after it passes through the filter and tested for stability as directed above.

Construction and Operation of Sewage Filters

By C. Kelsey Mathews
Associate Engineer, Burns & McDonnell Engineering Co.,
Kansas City, Missouri

Ordinary domestic sewage is composed of approximately 99.95% water containing mineral matter in solution and .05% suspended matter by weight. Approximately 40% of the suspended matter or only .02% by weight of the sewage is organic matter. Organic matter will decompose biologically and chemically by natural means and the products and process of decomposition are generally obnoxious to human interests.

Sewage disposal consists principally of the separation of the suspended matter from the liquid and the control of its decomposition. Pioneer attempts at sewage disposal have been made to accomplish this in a single operation, for example, disposal by cesspools, septic tanks, land filtration, stone or sand filters alone and by coagulation in tanks with air. In every case, however, it has been found economical and desirable to resort to two or more operations for the accomplishment of the disposal. Modern practice consists of the separation of the disposal of sewage into rour principal operations; first, the



INTERMITTENT SAND FILTER IN GOOD ORDER

removal of large, floating solids by screens; second, the removal of the remaining very fine, or colloidal solids by coagulation in tanks with air or by impact and straining in filters; and fourth, the decomposition or reduction of the separated solids in tanks or filters or both.

All of these operations are co-related and the extent of each depends on the design, construction and operation of the plant as a whole. In other words, if one part of the plant is designed or operated inefficiently, an extra burden will be thrown on the other parts. The operations should be distinct, as the action desirable in one part of the plant may be inimical to the operation of another part. For instance, in a plant consisting of screens, settling tanks and filters, if the screens and scum baffle are insufficient the resulting formation of scum on the settling tanks will cause accompanying septic conditions therein which are detrimental to sedimentation and the removal of the heavier solids will be inhibited thereby. These conditions will also be detrimental to the operation of the filters for two reasons: first, some of the heavier solids and some floating matter will be carried over to the filter with resultant clogging; and second, the septic condition set up is contrary to the desired biological action in the filter which must reverse the septic condition in addition to performing its own function. Again, if the sedimentation tank is designed and constructed too small, a larger percentage of heavier solids will be carried over to the filter, or if the sedimentation tank is too large with a consequent long retention period, or the outfall sewer is long, septic conditions may exist which will increase the amount of colloidal matter for the filter to handle. This condition, which is primarily the fault of design, may be improved in operation by prechlorination. Odors which are generally charged to filters very often are attributable to faulty design or operation of the settling tanks.

Sewage filters in a modern disposal plant should therefore be considered as performing a distinct function dependent on preliminary treatment. Economical treatment preliminary to the filters should provide a liquid from which 60% to 70% of the settling solids in the original sewage have been removed, and which is only slightly more septic than the raw sewage. Settling of raw sewage in direct contact with digesting sludge, a condition which exists in the septic tank or Imhoff tank, will not provide this treatment as efficiently as separate settling and digestion tanks.

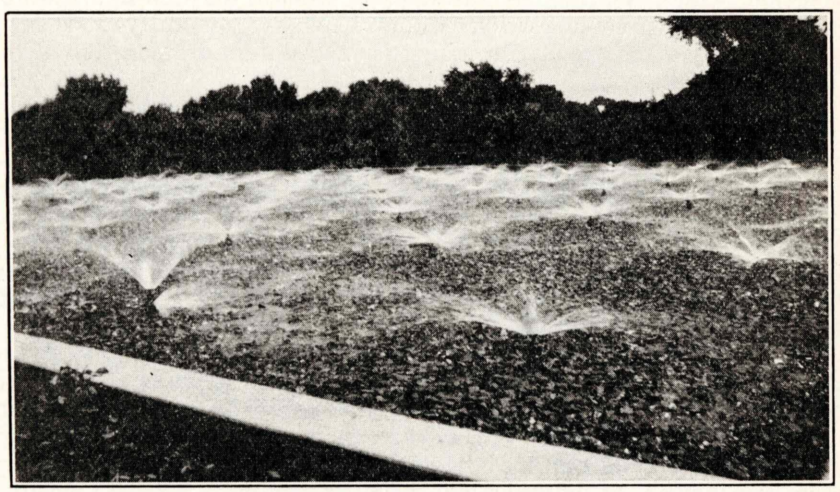
The purpose of a sewage filter is two-fold; first, to coagulate and settle the colloidal solids, and second to oxidize the remaining organic matter. The coagulation and settling action is by impact, agitation, mechanical straining or adhesion in the passage of the liquid thru the filter material and its bacterial humus. The oxidation is caused by the action of bacteria or their by-products within the filter medium in the presence of atmospheric oxygen.

There are three distinct types of sewage filters in use at the present time. They are generally known as sand filters, contact filters and trickling filters respectively. The common characteristics which are necessary for satisfactory operation are sound filter media, uniform dosage, sufficient aeration, and proper underdrainage. The common results characteristic of improper construction or operation are odors, clogging and insects. The distinguishing characteristics are rate and manner of dosage, type of filter media, depth of filter and head necessary, quality of effluent and cost.

Sand filters are characterized by intermittent dosage at low rates, fine filter media with open under-drainage, shallow depth and small head necessary. It is possible to obtain a much better quality of effluent from sand filters than from the other two types of filter. The first cost of sand filters is generally considerably higher than for the other types and winter operation is more difficult.

Ordinary domestic sewage may be applied to the surface of sand filters by troughs at rates varying from 100,000 gallons to 200,000 gallons per acre per day in from two to four doses, thus allowing aeration of the bed. The sand should have an effective size between .30 min. and .50 min. with a uniformity coefficient less than 3.0 and should contain less than 1% smaller than 0.10 min. The depth of the filter media should not be less than three feet and the total head necessary thru the dosing tank and filter may vary from 4 to 6 feet. In a well designed and operated intermittent sand filter plant the effluent will have the appearance of clear water and will be completely nitrified and will contain dissolved oxygen.

Contact beds are characterized by intermittent dosage in a water



THRICKLING FILTER SHOWING EFFECT OF BROKEN AND BENT SPRAY NOZZLES

tight tank on a fill and draw principle. The rate of dosage may be higher than for sand filters, and the depth of bed and head necessary slightly greater. The filter media is comparatively coarse and the quality of effluent not so high. The cost of contact filters is less than for sand filters.

Ordinary domestic sewage may be applied at any point in the depth of the contact bed at rates varying from 600,000 gallons to 900,000 gallons per acre per day in from two to four doses with rest periods of three to four hours between doses. The filter media should be hard stone varying in size from 1/4 inch to 1 inch. The depth of the bed should be five or six feet and the total head necessary thru the dosing tank and bed may vary from six to nine feet. The effluent from contact beds may be clear and without odor but requires diluting water to maintain stability. Since the development of trickling filters, the construction of contact beds practically has been discontinued.

Trickling or percolating filters are characterized by practically continuous dosages thru sprays at high rates, coarse filter media with open under-drainage, comparatively great depth and head necessary. The effluent obtained from trickling filters is ordinarily more stable than from contact beds, but cannot be expected to be non-putrescible if discharged into a dry ditch or allowed to stand in pools. The first cost and operating cost is less than for the other types of filters.

Ordinary sewage may be applied on trickling filters at rates of from 1.5 m.g.d. to 2.0 m.g.d. per acre. However, the criterion for design should be the connected population or equivalent population adjusted for industrial wastes, and the volume rather than the area of filter material should be considered. The dosage may be continuous or intermittent with rest periods of a few minutes duration, but the important feature of design and operation is that the dosage shall be uniform throughout the bed. The filter media should be hard, durable, stone varying from one inch to three inches in size. The depth of the filter media should be six or seven feet and the total head necessary thru the dosing tank and filter will be eleven or twelve feet.

These types of filters are different in detail, but the desired action in all is essentially the same. The oxidizing agents are bacteria, which need ideal conditions for functioning properly. The filter is therefore a sensitive unit. It is also the most expensive structure in a disposal plant, and any expenditure tending to facilitate inspection and operation is economical. The first cost of a filter may be reduced by stinting the capacity and construction features, or the operating costs may be reduced at first by inadequate attention, but any such false economy will ultimately occasion increased cost in depreciation, replacements and repairs. The filter should be designed and operated, in conjunction with the other plant structures, in the same manner as any other expensive piece of machinery.

Causes of Nuisances in Sewage Treatment Plants

By Lafayette Higgins, Sr.
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Putrefaction of the organic constituents of sewage is the primal cause of all nuisances resulting from methods of sewage disposal. The offensive gases released in the rapid transformation of the organic matter into harmless inorganic matter constitute the nuisances, as noted and determined by the physical sense of smell, and as defined by statute.

That a sewage treatment plant may be designed installed and operated so that nuisances will not occur has been well demonstrated, but if in either the design, the installation, or the operation, fault or neglect exists then nuisances will result.

The processes of sewage purification commonly employed are sedimentation, digestion and filtration.

The visible solids that by sedimentation and digestion are intended to be purified in the sewage tank are the source of nuisance in the tank. If the tank is functioning properly under the care of the operator a nuisance rarely occurs, but neglect, or lack of care, will easily furnish the conditions favorable for the release of the highly objectionable gases.

With one-story tanks, commonly called septic tanks, the digesting and ripening sludge collects at the bottom of the tank. A certain amount of the sludge is lifted by gases of the sewage in the tank. Such top sludge, or scum in continuing its digestion and purification, releases the objectionable gases immediately to the atmosphere if the tank is of open construction, but more tardily if the tank is covered or housed. The gases from the decomposing solids in the bottom of the tank normally break up or recombine in the liquid sewage above the sludge, and under proper functioning do not cause a nuisance. It often happens, however, that the tanks are allowed to accumulate sludge in the bottom, and also to build up the top scum in an excessive depth, until at the inlet end of the tank the bottom sludge meets the lower strata of the top scum, whereupon a nuisance occurs. Such a condition may be partially due to faulty design and installation, though in most cases it is directly chargeable to neglect or inefficient care.

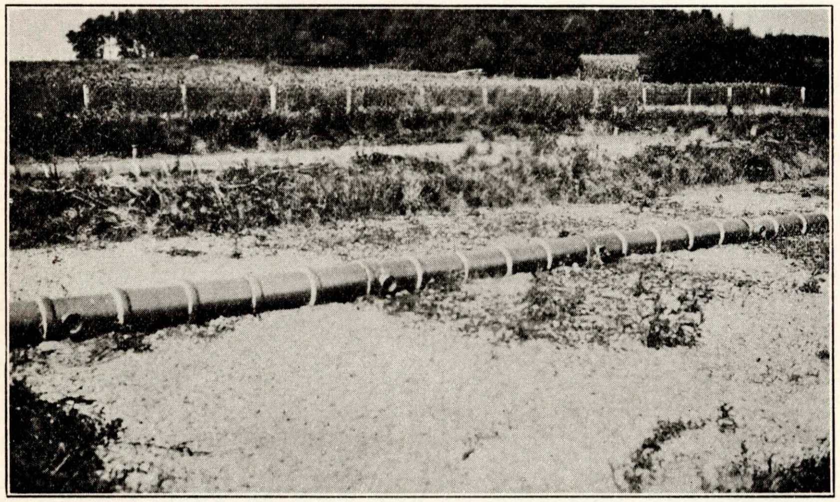
With two-story tanks the possibility of creating a nuisance is minimized by design and construction. Neglect or lack of proper care may however, cause such tanks to produce worse nuisances than

occur with one-story tanks. The ultimate result of neglect of one-story tanks is no tank purification, the sewage simply maintaining a channel of flow through the tank. Neglect of the two-story tanks usually results in foaming and overflow of the sewage, inundating the tanks and surface of the ground adjacent. In an isolated location this condition might prevail until the lower story of the tank became clogged with quiescent sludge. The upper chamber would then operate as a small septic tank which would soon become sludge filled and as is the case of any neglected one-story tank, the conditions would all be present which cause and perpetuate objectionable nuisances.

Evidently the real problem of the sewage tank is in handling and controlling the amount of sludge accumulating in the hoppers and the successful removal of this sludge from the tank.

Only well ripened sludge should ever be drawn from a sewage tank. A very small proportion of poorly ripened sludge, and a still smaller proportion of raw sewage, escaping with the discharged sludge will cause septic action in the sludge bed and thereby perpetuate a nuisance.

It is very difficult, and requires much time and patience, to successfully remove the well ripened sludge from one-story tanks. It often happens that the entire contents of a one-story tank will be discharged in removing the sludge. In such cases the contents of the tank generally go directly into a nearby stream, or whatever may be the outlet from the plant. This practice may cause a nuisance, and of course is to be condemned.



INTERMITTENT SAND FILTER OVERGROWN WITH WEEDS

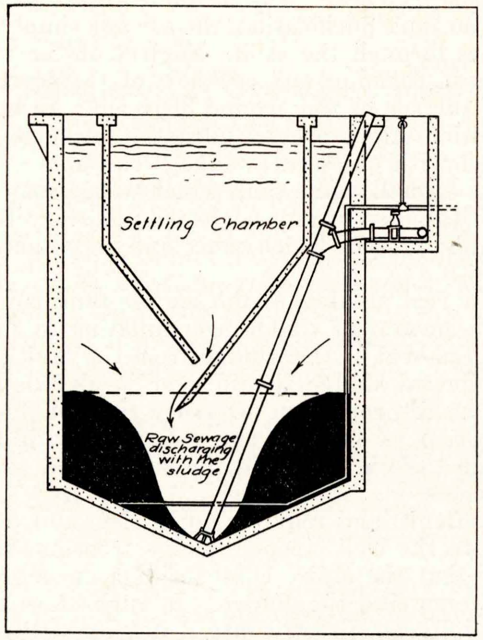


FIG. 1. IMHOFF TANK SHOWING EFFECT OF TOO RAPID DISCHARGE OF SLUDGE.

With two-story tanks there is little excuse for the existence of a nuisance resulting from sludge discharge. In a few instances the tanks have not funtioned properly for some months and the sludge in the digestion chamber is not well digested under such conditions. Such sludge will become septic in the sludge bed and cause a nuisance. For such behavior in the tanks there are causes which may be rather easily corrected, after which the sludge rapidly improves and soon becomes well ripened.

Fig. 1 shows what happens when the operator tries to discharge the accumulated sludge at one drawing. By this procedure much partially digested sludge and raw sewage escape to the sludge bed to set up septic action and cause a nuisance.

Fig. 2 shows the discharge of seven months' storage of sludge on to a sludge bed in January zero weather. Fig. 3 indicates the process by which the sludge was removed from the hopper, the dotted lines showing the relative level of the sludge after each drawing.

As indicated, three drawings were made, all within a period of four hours. Rest periods to allow the sludge to slide down in the

tank occupied about thirty minutes each. The sludge was irrigated by means of the perforated lead water pipe on the floor of the tank before beginning the discharge. The water entrained with the sludge drained away rapidly after the whole had been allowed to flow onto the sludge bed. What was done at this tank in discharging sludge can be done with any properly designed and installed two-story tank, and the nuisance commonly resulting from the discharge of sludge can be avoided.

The nuisances resulting from neglected filters are not so serious in themselves, but such conditions very quickly put the filters out of commission. Ordinarily trickling filters are not causing serious nuisances and a very little care will prevent any appreciable nuisance. It is understood that any filter may give poor results if overloaded, and in such cases the unloading of a trickling filter may cause a serious nuisance in the outlet stream. Both the suspended and dissolved solids in the tank effluent are supposed to be removed and purified by trickling filtration. With proper design and sufficient capacity the trickling filter is highly successful. It also requires a minimum of care.

Fig. 4 shows a successful trickling filter—the effluent being nonputrescible. No nuisance exists either at the filter or in the outlet ravine.

With sand filters the results are excellent with proper design, adequate area, and constant care in operation.

The tank effluent flowing upon a sand filter carries its dissolved solids into the sand filter but the suspended matter lodges on the sur-

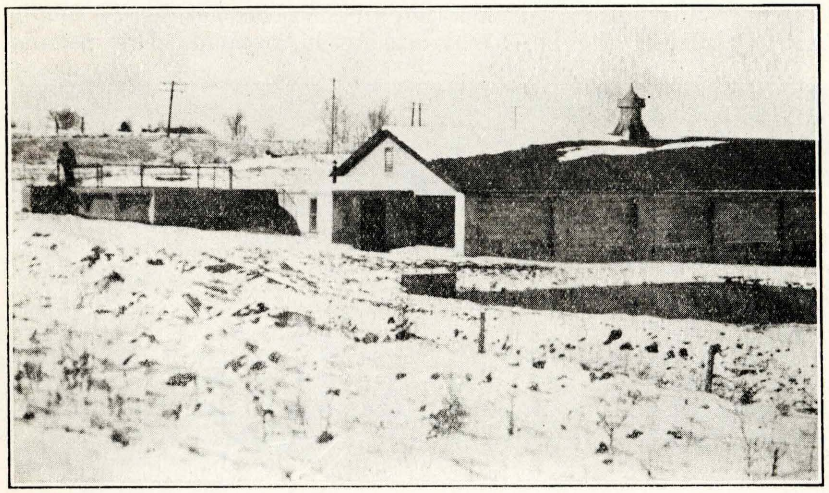


FIG. 2. DISCHARGING SLUDGE IN WINTER.

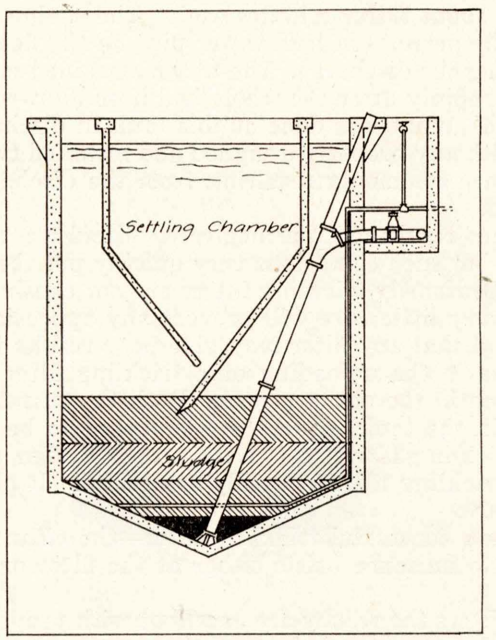


FIG. 3. IMHOFF TANK SHOWING PROPER METHOD OF WITHDRAWING SLUDGE.

face of the filter and slightly below the surface. This surface lodgment is readily penetrated for a time; it then becomes denser, finally partially sealing the filter and causing it to pond. This usually

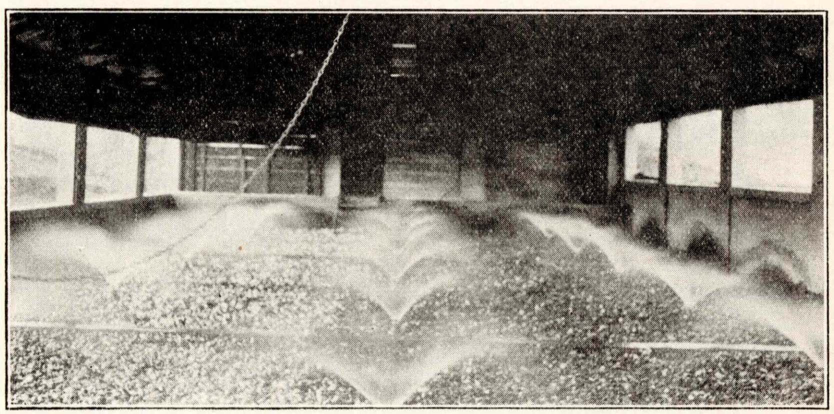


FIG. 4. COVERED TRICKLING FILTER

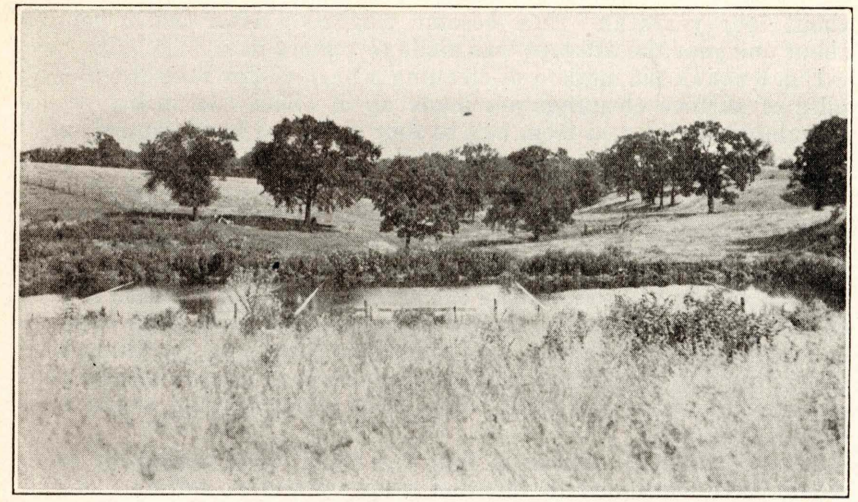


FIG. 5. SAND FILTER CLOGGED AND PONDED

causes some nuisance. If ponding continues long the sand filter cannot be aerated. The colloidal matter on the sand will not be oxidized and the filter will soon become permanently clogged.

Fig. 5 shows a ponded sand filter that functioned perfectly for

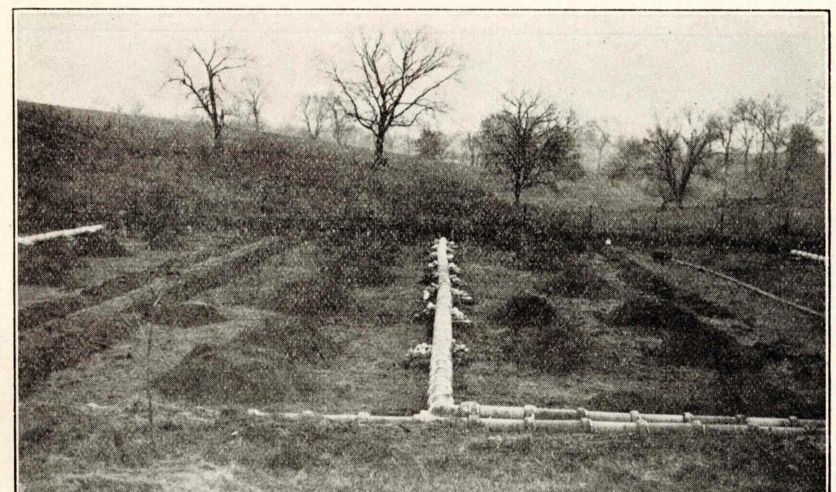


FIG. 6. METHOD OF CLEANING SAND FILTER WHICH HAS BECOME CLOGGED

about four years and then became clogged. After being ponded about one year the attempt was made to restore it.

Fig. 6 shows the method of cleaning a part of this sand filter. The piles of surface cleanings are made up of about two inches of accumulated sludge and from two to four inches of badly fouled sand. In many places the blackened sand extended to the underdrains and was removed.

Fig. 7 shows the same section cleaned and restored to perfect level with a hope that the filter might again function satisfactorily. It was found, however that the years of neglect and the long ponding had resulted in so reducing the aeration that the colloidal matter of the tank effluent collapsing on the sand grains, with little aeration to support purifying action, had permanently clogged the filter. Evidently the only immediate relief in this case is to remove all the sand and replace with clean sand. This filter if not isolated would be a serious nuisance.

A reasonable conclusion is that the filter, with reasonable care, would have continued to function properly and no nuisance would have occurred.

This experience has been duplicated many times in Iowa and it is a safe guess that at the present time the majority of the sand sewage filters are either in the condition shown or are rapidly reaching such condition.

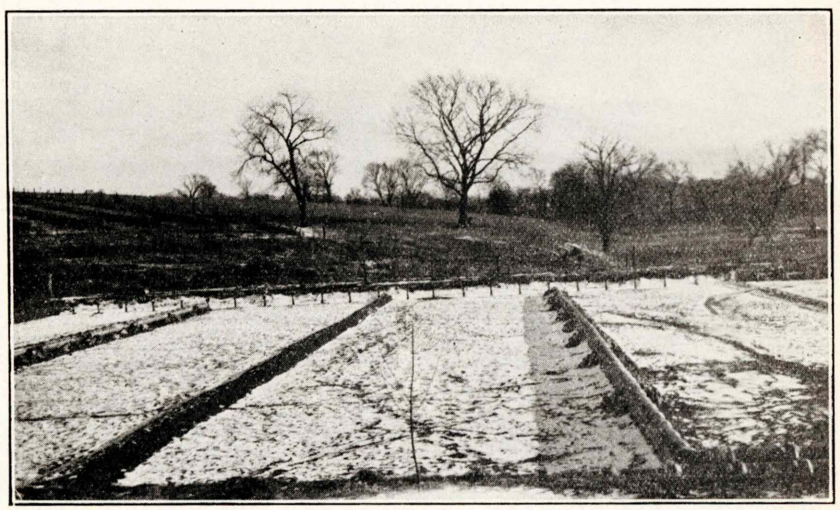


FIG. 7. SAND FILTER CLEANED AND LEVELED

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