will reduce the water content of activated sludge to about 60%.

It is interesting to note that in the further drying of activated sludge by artificial means, objectionable gases are given off which, unless carefully looked after, may create a local nuisance.

The fertilizer value of activated sludge is high, as both Bartow and Hatfield* and G. P. McKay and the writer† have pointed out. Mr. McKay and the writer have shown in actual outdoor plot experiments, subsequently confirmed by greenhouse plot experiments, that activated sludge, compared with barnyard manure, will produce yields of vegetables of extraordinary size. Results showed increases in the outdoor crop yield amounting from 100% in the case of lettuce to 290% in tomatoes, and even 550% in the case of Weatherfield onions. The results under glass, which have not yet been published, are equally remarkable.

Combination May Solve Problem

Owing to the difficulty and cost of dewatering, the trouble involved in the drying process, and certain other objections, the activated sludge method is not the last word on sewage disposal. It looks as though the solution of the sludge problem will depend upon a combination of the activated sludge process with sludge digestion or plain sedimentation tanks followed by trickling filters and sludge digestion. The latter will be controlled under definite conditions which are now fairly well established, and will be operated as a distinctly biological problem.

The practice to be followed will of necessity in small installations be more or less empirical, since expert assistants will not be available. This defect, of course, might be overcome by having the smaller sewage disposal plants placed under the indirect supervision of some qualified expert, who could keep them under proper working conditions and advise as to changes in methods of operation, additions to or modifications of the plant, from time to time as needed.

The principles underlying the activated sludge process and the trickling filter may seem to be quite different. As a matter of fact, they are identical. In the trickling filter some medium, whether it be stone or brush as in the Leaside plant, is employed, over which the sewage slowly trickles. The stone or wood after a time becomes covered with a slimy material which has the property of absorbing solids, colloidal material and other inorganic compounds from the thin sewage films flowing over it, and of converting this absorbed matter, through biological oxidation processes, into inert, non-putrescible, inorganic matter.

In the activated sludge process this same kind of slimy material which forms on the surface of a trickling filter is gradually produced by bubbling air through sewage held in tanks. When fresh sewage is agitated for some hours with this activated sludge by streams of fine air bubbles, the organic matter in the sewage is attracted to the activated sludge just as it was attracted to the slimy film on the stone or wood trickling filter, and is so altered that only inorganic, non-putrescible materials pass over in the clarified effluent.

Different Methods, Same Principle

In the one case the sewage circulates through the air over an activated biological medium; in the second case the activated biological medium is circulated through the sewage in association with large quantities of air bubbles. The combination of ærobic bacterial agent and air is identical in both methods. That this biological agent is identical in both cases was proved by the writer, who started a small activated sludge tank with ripened sludge collected from a lath trickling filter. The nitrification and clarification, which usually takes several weeks to develop, began at once, proving that the biological medium was one and the same, and that the processes were identical.

In the opinion of the writer, the complete solution of the sewage disposal problem will come about finally through a combination of the activated sludge process, or trickling filters, with sludge digestion. It may be that the activated sludge process will be the preliminary installation, followed by digestion tanks; or it may be that actual sewage digestion will be the first installation.

Brush Affords Greater Capacity

In one of the common types of sewage disposal plants, sedimentation tanks remove the larger part of the suspended organic matter, and the effluent is treated on trickling filters or oxidizing beds. These may be of stone, clinkers, brush or other material, and the general rate of treatment has been from two or two-and-a-half million gallons of sewage per acre per day on the older form, to seven million gallons per acre per day on the newer brush filter.

Where plenty of fall is available, trickling filters, particularly in small installations, will frequently be considered preferable to the activated sludge method. At the Leaside, or North Toronto, sewage disposal plant, one of the trickling filter beds, composed of stone, was at my suggestion replaced some six years ago with bundles of brush tightly packed together. Operating side by side for six years, the other old stone filters have treated from two to two-and-a-half million gallons of sewage per acre per day, while the brush filter has averaged six-and-a-half million gallons per acre per day.

The brush filter was simply the logical conclusion of experiments carefully conducted by us at our experimental plant to determine the greatest amount of filter medium which, allowing free access of air, could be packed in six feet of filter bed. This method, which was patented at the time, is free to those who wish to use it, and, since it is cheap and will reduce the amount of filter area required to one-third, there should be many places where its use should prove desirable.

It may be stated here that the brush to date shows absolutely no signs of decay, and is as sound as it was six years ago when placed in situ. With this method, of course, the sludge problem has still to be dealt with.

Can Digest Sludge Inoffensively

Though it has not been possible to digest sewage anærobically and obtain a non-putrescible residue without offense, it has proved possible to digest sludge without creating a nuisance. Watson, of Birmingham, has shown* that sewage sludge can be thoroughly digested on a huge scale without causing a nuisance. At Birmingham the fresh sludge from ordinary sedimentation tanks is drawn off and pumped into digestion tanks, receiving before it enters these tanks one-fourth its volume of old, thoroughly ripened sludge. This seeds it with the proper bacterial flora, and, provided the temperature is right, digestion will progress to a conclusion without the production of foul odors. At the end of four months the sludge is thoroughly digested, is no longer putrescible, is reduced in quantity and is readily drained on ordinary drying beds.

The action which occurs in the Birmingham sludge tanks is apparently the same as that which occurs in a properly operated Imhof tank. Dr. Carl Imhof, while on a visit to Toronto in 1913, told us that it was quite feasible to digest sewage sludge without offense. He advocated the mixing of one part of Emscher (Imhof) sludge with one part of fresh sludge, and stated that a ripened sludge would be produced in one week. One part of this could then be mixed with an equal volume of fresh sludge, and so on, ad infinitum. The Emscher sludge itself takes from nine to twelve months to prepare.

Those attempting to solve the sludge problem have in mind two definite objectives. In the first case, an attempt is being made to save the tremendous waste of valuable nitrogenous matter present in sewage, and retain it in the

*See Journal of Industrial and Engineering Chemistry, Vol. 8, No. 1, January, 1916.

†See article, "Fertilizer Value of Activated Sludge," by G. G. Nasmith and G. P. McKay, in *The Canadian Engineer*, May 2nd, 1918, page 377.

*See "The Utilization of Sewage Sludge," by John D. Watson, in *The Canadian Engineer*, October 30th, 1919, page 420.