SOME RECENT EXPERIMENTS IN SEWAGE TREATMENT AT EXETER.*

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OF late years the microbe has been notorious rather than famous, being known to the world chiefly as the spreader of certain virulent diseases. The misdeeds of these "pathogenic" or disease-producing organisms have brought the whole tribe into undeserved disrepute. Indeed, the chemical systems of sewage treatment owe their popularity largely to the acute attack of microphobia from which the British public still suffers. It is claimed for these systems that the precipitants used either destroy, or throw down with the sludge, most of the pathogenic organisms present in the sewage. This no doubt they do, but it is a mistake to suppose that the germs of infection are thus got rid of. The sludge, or sludge cake, from a sewage containing disease germs may easily become the vehicle for spreading the disease far and wide; while the freeing of the liquid sewage from micro-organisms, far from being an unmixed advantage, is an apt illustration of the risk we run in rooting up the tares of rooting up also the wheat with them. In ridding sewage of pathogenic organisms we deprive it also of those other organisms which are alone able to bring about its purification. The sewage is thus more or less sterilised, its purification being arrested until its stock of microbes can be again made good. This takes place when the effluent is discharged into a stream; when we have the familiar phenomenon of deferred putrefaction.

Such considerations as these forced me to the conclusion that no system of treating sewage can be satisfactory which does not follow as closely as possible the lines laid down by nature. I therefore set myself to devise a system in which the work of natural agents should be forwarded to the fullest extent. For many years past, in such leisure as I could snatch from the duties of a very exacting position, I have devoted myself to researches and experiments, with a view to ascertain what condition would best further the desired object. Of this work the septic tank is the outcome.

In this system no chemicals are employed, and there is no "treatment" of the sewage in the ordinary sense of the term, its purification being accomplished entirely by natural agencies.

The septic tank itself is merely a receptacle designed to favour the multiplication of the micro-organisms, and bring the whole of the sewage under their influence. To this end the tank is of ample size, though not larger than would be necessary with chemical precipitation, and covered so as to exclude light, and, as far as possible, air. The incoming sewage is delivered below the water level, and the outlet also is submerged, with the twofold object of trapping out air and avoiding disturbance of the upper part of the contents of the tank. On entering the still water of the tank, the solids suspended in the sewage are, to a great extent, disengaged, going either to the bottom or to the surface according to their specific gravity. In the absence of light and air, the organisms originally present in the sewage increase enormously, and rapidly attack all the organic matter. By their action the more complex organic substances are converted into simpler compounds, and these in turn are reduced to still simpler forms, the ultimate products of the decomposition in the tank being water, ammonia, and carbonic acid and other gases. Other nitrogenous compounds may also be present, but they will all be soluble in a slightly alkaline solution, a condition which obtains with every normal sewage.

No sludge is found. Examination of the bottom of a tank which has been in use for six months reveals only a thin layer of black earthy matter, the burnt-out ash of the solids of the sewage, together with the mud and grit brought down by storm water. So far as accumulation at the bottom is concerned, it would seem that a tank may be used for an indefinite time without requiring to be cleared. The larger part of the solids in the tank are found at the top, where a somewhat tenacious scum soon forms, consisting of the lighter solids in process of decomposition. The intensity of the action going on is evidenced by the large bubbles of gas which everywhere break through the scum. Here is probably the chief seat of the bacteriological action by which the solids are eventually thrown into solution. As soon as most of the organic matter in a solid substance is dissolved, the ash falls to the bottom, where decomposition continues its work. Presently a bubble of gas is formed, which buoys a fragment of ash and brings it again to the underside of the scum. The bubble soon becomes disengaged, and the ash falls again to the bottom. There is thus a constant interchange between the upper and lower layers of the tank, whereby its solid contents are brought under the most favourable conditions for rapid decomposition and solution. After a tank has been a short time at work, the scum increases in thickness very slowly. In one case, after 13 months' work, the scum was only a few inches thick.

The effluent from the tank is comparatively clear and inoffensive, and not liable to any after-fermentation; the work of decomposition being already done. In this state there can be no reasonable objection to its discharge into tidal water. It is eminently fitted for utilisation on land; containing as it does all the constituents of the sewage having any manurial value, in a form immediately available as food for plants, while its freedom from suspended matter removes the difficulty met with in irrigation with crude sewage. It is also in a fit state for filtration.

The filtration of sewage or sewage effluent is not a mere straining action. If it were so, the filters would soon clog and become useless. Moreover, the effluent from the septic tank, being free from solids, is not susceptible of improvement by straining. The work to be done consists in the oxidation of the ammonia formed in the tank. This is thus converted into nitric acid, which at once combines with the bases present to form nitrates.

This oxidation, like the previous decomposition, is the work of micro-organisms, but of a kind totally different from those which operate in the tank. The latter are largely of the species classed as anaerobic, living in the absence of air and light, and exercising in many cases a reducing or deoxidising action. The organisms which work in the filter, on the other hand, are aerobic, the presence of oxygen being absolutely necessary for their life and work. Consequently the conditions prevailing in the tank must be reversed in the filter, to which oxygen must be freely supplied.

To this end the filters are best constructed of some porous material, such as coke breeze or crushed furnace clinker, affording abundant interstitial space. Furthermore, as has been shown by the experiments made for the Massachusetts State Board of Health, and those of Mr. Dibdin, chemist to the London County Council, filtration must not be continuous, or the oxygen contained in the filter will soon be consumed, when the nitrifying organisms will die off, rendering the filter useless until new colonies shall be formed. Filtration, therefore, must be intermittent, a charge of air being supplied to the filter after every dose of effluent. It is found that a

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filter worked in this way retains its purifying power for an indefinite period.

At the North London Outfall Works at Barking the intermittent action of the filter is secured by keeping a man constantly on the spot to fill and empty it at the proper times. For the 24 hours three men are required, working in shifts of eight hours each. In my system attendance is altogether dispensed with, an arrangement being adopted whereby the filters are filled and discharged automatically.

In a small plant the filtering area may be divided into two parts, each of which would be filled in turn, while the other is emptying and at rest. The action of the alternating gear is as follows: The supply of effluent to each filter, and the discharge of the clear water after filtration, are controlled by valves, all connected to one rocking shaft. The clear water from each filter passes into a bed of gravel underlying it, from which it is led by drains into a collecting well. As the effluent fills the filter the clear water rises in the collecting well; and when the filter becomes full a small quantity of clear water overflows from the collecting well into a bucket carried by the shaft. The water thus thrown into the bucket bears it down, rocking the shaft, and thereby actuates all the valves. The flow of effluent to the filter already full is stopped and its discharge valve opened, the effluent being turned on to the empty filter, whose discharge valve is at the same time shut down. The water rushing out from the filter last in use draws down after it through the filtering material the charge of air required for dealing with the next dose of effluent. When the bucket which rocks the shaft sinks into its lower position, its contents are discharged through a counterbalance chamber, in which a part of the water remains to hold the valves in place until the other filter shall be full. The overflow from this second filter passes into another bucket, which was raised into position by the sinking of the first, and by means of which the valves are brought back into their original position.

The first set of alternating gear installed was naturally regarded with the wholesome distrust engendered by sad experience of automatic devices, but six months' working has demonstrated its absolute reliability.

The first working installation consisted of a small tank only, which dealt with the sewage of over 30 houses, as well as that of a large reformatory. It also received a considerable amount of storm water. This tank was in use for 13 months, during which it gave a uniformly clear effluent. At no time was any solid matter taken out of it, nor did it require cleaning at the end of the period.

The fitness of the tank for its work having thus been demonstrated, a second plant was laid down to deal with the sewage of over 300 persons, ranging from 7500 to 10,000 gallons daily. In addition to the tank, two coke breeze filters were provided, having a united area of about one-hundredth of an acre, and furnished with the alternating gear before described. The gratifying experience gained with the first tank has been confirmed by the second, while the uniform good results given by the filters show how completely the tank does its work of preparing the sewage for filtration.

The filtered effluent is quite free from smell, and in the bulk of a large tumbler shows the merest trace of colour. It is often absolutely colourless. Analyses show that it comes up to the exacting standard of purity laid down by the Rivers Pollution Commission. These results were somewhat unexpected, seeing that a two-filter plant does not admit of that period of rest after filling and before discharging which has been regarded as necessary.

The further subdivision of the filtering area which would be practicable in a larger plant would give better results.

This plant has frequently been subjected to flows many times in excess of its normal capacity, without suffering any noticeable deterioration. The conditions under which it is working are those which would be met with in ordinary practice in dealing with the sewage of 300 or 400 people.

In view of the results thus obtained, the Exeter City Council, guided by the reports of chemical and bacteriological experts, have adopted the septic tank system for the disposal of the sewage of the whole city, subject to the sanction of the Local Government Board; and plans of the proposed works are now in hand. For more complete demonstration of the capabilities of the system, the council have constructed a larger plant to deal with the whole flow of one of their outfall sewers, amounting to 90,000 gallons per day.

This installation, which has just been completed, consists of a tank 64 ft. by 18 ft. ranging in depth from 7 ft. to 10 ft., with five filters 5 ft. deep, filled with coke breeze and furnace clinker, and having a total area of 400 square yards. One filter will always be held in reserve, the four others being worked in one cycle, in the same way as the two-filter plant already described. By having four filters in a set instead of two, it becomes possible to give each filter a period of rest after filling before it is emptied, and a period for more complete aeration after each discharge.

Instead of straining off the floating solids and intercepting the road grit outside the tank, it was decided to turn into it all the solids brought down by the sewer, so as to place it under exceptionally severe conditions. The only outlet is the effluent discharge pipe, 6 ft. above the bottom, there being no other avenue by which either solids or liquids can escape from the tank.

The foregoing description deals only with the main features of the system, passing over those minor details which do not affect its fundamental principles, though they are none the less necessary for insuring constant and reliable working. The tank is protected by patent, and a patent for the alternating gear has been applied for.

Besides the installation already referred to, and a few others in actual operation or in course of construction, the Town Council of Yeovil have a plant in hand which is interesting as being the first attempt to deal with a sewage strongly charged with manufacturing refuse. So far as I can see, the system is as capable of dealing with a sewage of this kind as with an ordinary domestic sewage, though there are doubtless exceptional cases in which manufacturing wastes, or some of them, would need special treatment.

A question naturally suggests itself with regard to pathogenic organisms. If, in order to purify our sewage, we provide conditions favourable to the growth of micro-organisms, will not the germs of disease be thereby retained alive, or even increase in number? This question can be answered with a decided negative. Micro-organisms in general, and those of disease in particular, are peculiarly sensitive beings, requiring certain well-defined conditions as to food, temperature, and so on. During the passage of sewage through the tank and filters, any organisms contained in it are subjected to complete changes of environment. First we have the dark airless tank, then free exposure to light and air in the effluent channels, and lastly, the subjection to strong oxidising agents in the depths of the filters. During each of these stages any organisms originally present in the sewage are liable to be preyed on by others better adapted to the conditions in which they are placed. The experiments of the Massachusetts State Board of Health prove that the chances of microbes surviving the passage through a filter are infinitesimal.

In the matter of cost the advantage of the septic tank system is not less marked than in that of efficiency. The capacity of tanks and filters required is not greater than with chemical processes, and the whole cost of machinery for preparing chemicals, agitating, and dealing with the sludge, and buildings for its accommodation and for storage of sludge, is saved. The only additional item of cost with the septic tank system is the alternating gear, the valves themselves being common to both systems. The annual cost of working is practically *nil*.

Not the least advantage of the system is its power of dealing temporarily with volumes of sewage far in excess of the normal capacity of the plant, a feature which renders it possible to abandon the risky expedient of discharging slightly diluted sewage without treatment whenever the volume of dry weather flow is slightly exceeded.

With this system the difficulty often experienced in finding a suitable site for works of sewage disposal is reduced to a minimum; for a septic tank plant can be placed in situations where a plant on any other system would be impracticable.