

## THE NON-SEPTIC AERO-ANAEROBIC TREATMENT OF SEWAGE AND OTHER ORGANIC LIQUIDS.

*(A paper read before the Sydney University Engineering Society  
on August 12th, 1908.)*

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### INTRODUCTION.

The non-septic aero-anaerobic treatment of sewage, which will be briefly confronted with the septic and other systems, is but an advance in the application of past experience with observance to Nature's laws.

While in nature the organic matter finds in the soil conditions most favourable to its decomposition (air action, alkalinity, its minimum proportion in respect to the compound minerals of the soil); and, in any case, while it little matters in nature whether the phenomenon is carried out more or less rapidly, in cesspools or tanks in inhabited places, it is recognised that it is indispensable that the process of removal be rapid and hygienic. But the conditions indispensable to its carrying out are, unfortunately, in general the most contrary that one can imagine. It will not be necessary to dwell on the sewage system of buckets or cesspools, which are periodically emptied by methods more or less efficient, but attention will be confined to the evolution of sewage treatment by the process of decomposition, as it is carried on by nature to all dead organic substances (manure, excretion, organic refuse of all kinds existing in or added to the soil), and what can be done to improve the present ways of disposal by assisting nature in her work.

### WAYS OF DISPOSAL.

The ways of disposal of sewage are principally three:—

1. Discharge into rivers, tidal estuaries, or into the sea.
2. Biological treatment.
3. Treatment by chemicals or fire.

Only one of these three methods is to be advocated, i.e., biological treatment, as it alone combines:—

1. Incapableness of putrefaction.
2. Improvement of foul liquids into which it may be discharged.
3. Elimination of zymotic germs.

4. Economy; and
5. Utility as a fertiliser for vegetation.

#### DISCHARGE INTO THE SEA.

Sanitarians, in endeavouring to imitate nature, are working on lines which will ultimately meet with success. The remarks will, therefore, be confined to the evolution of nature's process, and will but touch only slightly on discharge into the sea, which, under certain conditions, is advisable, for these methods are the most practical, and, when efficiently carried out, meet all requirements. In certain cases it may be more economical to dispose of the untreated sewage into the sea, but such a course should only be resorted to when there is a true outward sea current, as the danger and nuisance from the backwash of this discharge on to the coast is too well-known to encourage it. The outlet being lower than the surface of the sea has the defect of forming a tank in that portion of the sewer which is below the sea level, where putrefaction is, in frequent cases, very pronounced, the imprisoned gas, if not carefully eliminated, being a source of danger. Spezia and many other towns on the Mediterranean Sea, and elsewhere, have had bitter experience of this, but with a true outward current the system can be made satisfactory. Recently at Malta this system has been adopted, and on a high site a tank has now been constructed, into which the sea water is pumped. This tank alternately discharges by two routes 10,000 gallons of salt water, which cleanse out the main drains most thoroughly. I was eight days there, and inspected with officers of the Public Works Department the entire plant. This town, Valetta, is one of the most populated towns in the world for the area it covers, and a section where poor people are collected contains more living souls in its area than any portion of any other known town in the world. Sliema, on the opposite side of the west harbour, is growing rapidly, and the conditions of hygiene were still till recently primitive; but when the fleet had to leave this port and harbour at Gibraltar, owing to the prevailing sickness and fever, the authorities determined to make the town and neighbourhood more sanitary. The question of fall in the sewers was decidedly difficult, but this has been overcome, and when the author left a pumping station was being put in between Arendi and Dingli, on the south, and on the high ground between these villages (the highest in the inhabited part of this rocky island) a receiving tank. In all these outlying villages drinking water is only obtainable by collecting the rainfall from roofs, so the question had to be overcome by laying piping from this salt water reservoir, and using it for sanitary purposes. Drains are now laid in some parts, and when the work is completed it will be satisfactory, for at the sewer outfall in the sea

there is an outward sea current which removes effectually all waste. To avoid the stagnation and putrefaction of the sewage in the final section of the sewer below the sea level, 10,000 gallons of sea water will be flushed through alternately, by Notabile and by Zurricco, to the Calcareo sea outlet. As a whole, and under the existing conditions, the system is, and will be, most satisfactory.

A description will now be given of the best means of disposal of sewage and other organic waste, where such favourable conditions do not exist.

#### BIOLOGICAL TREATMENT.

Biological treatment requires certain indispensable conditions which must be realised—that is, the tanks in which the organic matter is to be treated must be suitably constructed. The essential is, that these tanks be constructed so as to receive an adequate supply of air at the necessary period for the evolution of the initiative process, and so prepare the sewage by the process of decomposition for its final treatment on suitable filters.

#### HISTORY.—DISCOVERY.

It will be well first to take a hasty glance at the inception and growth of sewage treatment on biological lines. A French monk, Louis Mouras, in an accidental way, is the pioneer of the septic tank. A French biologist, Pasteur, is the pioneer, in a scientific way, of the filter.

#### MOURAS

Louis Mouras was much troubled by the expense of having the cesspool contents removed so often from his monastery near Paris, and, observing the quantity of liquid removed each time, his economical mind struck an idea, which he at once put into practice, and which is still, clandestinely, much in use in many towns in France, Spain, and Italy. He ordered his mason to knock a hole under the springing in the cesspool vault, and to make a closed channel from it to the street drain. In front of this opening, in the cesspool, he had placed a screen, open at the bottom, to hold back the solids. By this means Mouras calculated that the cesspool would require to be emptied only when full of solid matter. Shortly after war broke out with Germany, and Mouras's Monastery was occupied by soldiers. When peace was declared he returned to the monastery, and, astonished that the cesspool was not full and choked up by solids, he applied for the night artillery to come and empty it. Being interested, he watched the operation. His astonishment was, as he remarked, not small when

he saw that, beyond a leathery scum at the top, the entire solids were broken up; and, seeing the possibility of making something out of the application of such a system, he patented it; and later, on 9th December, 1881, through his agents, Haseltine, Lake and Co., he patented the system in England under the title "Cesspools." His patent had existed for a short time when the attention of the Paris Health Department was drawn to it, and, after being examined by a Commission, was condemned.

#### FILTER.

To go back to the origin of the filter one must go back to the discovery of microscopic organisms in water, which dates back to the seventeenth century. Anthony van Leeuwenhoek, born in Delft, in Holland, in 1675, published the fact that he had succeeded in perfecting a lens, by means of which he could detect in a drop of rain water living motile "animalcules," smaller than anything hitherto seen. But it was not until 1850 that the study of organisms in drinking water was recognised as having a practical sanitary value. Dr. Hassall, of London, was the first to call attention to this. His method of procedure is unknown, but in all probability it consisted of the examination of a few drops of the sediment collected after allowing water to stand in a vessel for a longer or shorter period. Radlkofer (1865), Cohn (1870), Hirt (1879), and Hulwa, pursued the study, and emphasised its importance; but they made no radical improvement in the method. While the study of organisms in water was proceeding, Pasteur, in 1860, discovered fermentation; but not until 1881 was the effect of bacteria on organic matter gone into. For this the honour is due to Frank Hutton, who made most extensive research. (He contributed the result of his researches to the Chemical Society in May, 1881, London. "Journal of the Chemical Society," CCXXII., p. 247.) Hutton's discovery was closely followed by Mr. Dibdin, then chemist to the London County Council, and who, if not the pioneer of filters, has ever been most closely connected with them. Dibdin, however, did not begin his experiment on filters till 1891.

Attention was first called to the successful experiments in the treatment of sewage by the State Board of Health of Massachusetts in the years 1888, 1889, and 1890. The results of these experiments show that filtration without air gave no nitrification, and the filtered effluent gradually became worse, until it contained as much organic matter as sewage. ("General View of Results," in the Board report). Valuable as were these results, they left the question of sewage disposal in an all but impracticable form, and this was due to want of preparedness in the sewage for filtration, and the use of too fine

filtering material, to the exclusion of air. Following up these experiments, the Main Drainage Committee of the London County Council instituted a series of experiments at Barking Creek. These experiments were by Mr. Dibdin's suggestion, and carried out by him. Referring to his first experiments, he said:—"We aimed at three things by filtering—to remove odour, liability to putrefaction, and colour. While we were carrying out these experiments the question was speedily taken up, with the result that Mr. Donald Cameron, then City Engineer to the Borough of Exeter, applied a tank, practically in idea similar to the Mouras, only much larger, with a view to bringing about the destruction of the solid matter in the sewage. This tank Mr. Cameron termed a septic tank, and under this title an anaerobic tank is now generally known. At the same time Mr. Scott Moncrieff, who has untiringly done so much, carried out a series of experiments at his residence, 'Ashstead,' where he placed a filter in his sewage tank, with results naturally far from satisfactory. Mr. Cameron was then in difficulties with the effluent from his tank, and I advised him to put in a filter, which he did, taking that at Barking Creek for his example." Mr. Scott Moncrieff subsequently arranged that the effluent from his tank should flow on to a series of filter trays, discharging one to the other, and here he met with a remarkably high degree of nitrification. Colonel Ducat, Mr. Stoddart, and many others came into the field, and the best means for the disposal of sewage became a question of keen interest. Slow has been the progress of hygiene in the past, but from a more intimate acquaintance with micro-organic life hygiene has attained at last the prominence and importance now justly accorded it. To enumerate or describe what has been done or suggested would fill a very large volume. We have to remove and dispose of sewage, a putrescible liquid, with due regard to hygiene, as economically as possible, and if but one step towards this end can be added the labour will not have been in vain.

#### SEPTIC AND NON-SEPTIC ACTION.

It will be well if at this stage a clear explanation of the difference between the construction and action of a septic and of a non-septic tank be given.

What is the aim of biologists and engineers in building a sewage tank?

It is to obtain a breaking up of the solids contained in the sewage, and prepare it so that the organisms in the filter can attack more effectually and more rapidly the organic matter.

Can this best be done by a septic tank?

No, it cannot, for the effluent from a septic tank cannot be advisable, as the condition of the tank is anaerobic and the filter aerobic. They are so opposite that to have the two classes in the filter-bed must lead to complications and delay.

Is any advantage gained by allowing the sewage to become septic (putrid)?

No. For compound forms of ammonia are brought about by the second fermentation, which have the effect of hindering the action in the aerobic filter.

A tank which excludes the contact of air cannot but produce an anaerobic decomposition, precisely what is aimed at in the septic tank, and anaerobic decomposition is putrefaction, accompanied by fetid exhalations. Notwithstanding these facts and that one says, "I will not have a septic tank at my door," and very properly so, it is still maintained by many that they are not offensive. But the author's advice is that everybody should live as far away from them as possible, and he has had to do with them in all climates and under most varied conditions. One sometimes fears our heads have become so firmly packed with false doctrines, especially in sanitary matters, that what ought to be counter-vailing facts cannot be got into them.

#### MICROBES.

Let us for a moment study the micro-organic life, which can live, and does live, in sewage, if we but give it suitable conditions. Micro-organisms, owing to the absence of chlorophyll from their compositions, are forced to obtain their nutritive materials from organic matter, and lead therefore either a saprophytic or parasitic existence. Their life processes are so rapid, complex, and energetic that the most profound alterations result in the composition and structure of the materials in and upon which they are developing. Fermentation, decomposition, and putrefaction result from the saprophytic groups of bacteria, while the changes brought about by the purely parasitic forms in the tissues of their host find expression in diseased processes, and not infrequently in complete death. The saprophytic groups of micro-organisms are divided into three classes (aerobic, anaerobic, and facultative), and their role in nature is a very important one. Through their activities the highly complicated tissues of organic matter (animal refuse and vegetables) are resolved into the simpler compounds (carbonic acid, water and ammonia, ammonia-nitrites, and ammonia-nitrates), in which forms they can be taken up and appropriated by the more highly organised members of the vegetable kingdom which do not possess the power of obtaining their carbon and nitrogen from the highly-organised and complicated substances that serve for the

nutrition of micro-organisms. Carbonic acid ( $\text{C.O}_2$ ) and ammonia ( $\text{N.H}_3$ ), as nitrites or nitrates, are decomposed into their elementary constituents by chlorophyll, the green colouring matters in algae and higher plants.

#### EFFECT ON LIFE.

Were it not for the activity of these microscopic living creatures all life upon the surface of the earth would cease, for life is one continuous cycle of three stages.

First.—Dead animal and vegetable life, by saprophytic micro-organisms, is resolved into simpler compounds—carbonic acid, water, and nitrites or nitrates.

Second.—The vegetable kingdom appropriates these as nourishment, without which its development would rapidly come to an end.

Third.—The animal kingdom has foodstuff supplied to it by the vegetable world, and finds life possible.

It is plain, therefore, that the saprophytes, which represent the vast majority of micro-organic life, must be looked upon as benefactors, for without them life's existence would be impossible. These micro-organisms are the agents of universal hygiene. They destroy more quickly the remains of all nutrition than the dogs in Turkish cities; they protect us not only against the dead, but it is to them we owe our lives.

#### MICROBE REQUIREMENTS

These micro-organisms, to do their work, must have carbon, nitrogen, and water, and we must not lose sight of the fact that the normal development of micro-organisms is influenced both by the quantity and quality of nutritive material to which they have access, and by the character of the products that accumulate in these materials as a result of their vital processes. Any excessive development of alkalinity or acidity, as a result of growth, arrests development, as no evidence of life or further multiplication can be detected until the deviation from the neutral reaction has been corrected. Under proper conditions one species of microbes is directly dependent on the functional activities of another totally distinct species, the growth of one group resulting in conditions that are of vital importance to the existence of the other. This inter-dependence of species is known as symbiosis.

#### FERMENTATION.

Saprogenic bacteria, which produce the particular fermentation that we know as putrefaction, must not have con-

ditions so as to prevail, otherwise there is the development of sulphuretted hydrogen gas (odour of bad eggs), and the effluent becomes bad as it is offensive.

A question frequently asked is, "What is the difference between fermentation and putrefaction?" The cocchi, bacilli, and spiralli, principally cocchi, which set up fermentation, produce many and most varied results. For example, take the science of wine making, which is now largely understood. Each quality of grapes contains a distinct ferment flavour. Take 100 parts gorgotesco grapes and one part cannaiole grapes; start a natural healthy fermentation in the cannaiole grapes, and when the scum (or cap) has formed break up the hundred parts of gorgotesco grapes and add the one part cannaiole in fermentation. The whole mass will be invaded by the ferment cocchi of the cannaiole before the gorgotesco ferment has had time to come to life, and the whole will take the flavour of cannaiole. The same will happen from muscatel ferment, or any other desired grapes. But if the wine is deficient in alcohol, we may expect our Cantiniere to inform us that one or more of the wine vessels containing this tasty wine have gone bad with "Mercuriel"—that is, the wine is gone putrid by this second ferment life, and is undrinkable. It may be, provisionally, partially remedied, but it is spoiled to the taste, and will not keep. The micro cocchi and their multiplication are hard to describe in popular language. When viewed under our highest microscopical powers they appear as little larger than specks on paper. A millegramme is about the sixty-fifth part of a grain, yet no less than 8,000 millions of microbes were estimated by Bujivid in this small volume. Their rapid multiplication under favourable conditions can best be described in the words of Cohn: "Let us assume that a microbe divides into two within an hour, then again into eight in the third hour, and so on. The number of microbes thus produced in twenty-four hours would exceed  $16\frac{1}{2}$  millions. At the end of 24 hours, the microbes descended from a single individual would occupy one-fortieth of a hollow cube with edges one-twenty-fifth of an inch long; but at the end of the following day would fill a space of twenty-seven cubic inches, and in less than five days their volume would be equal to the entire ocean." It is needless to say these figures are purely theoretical, and could only be attained if there were no impediments to such rapid increase. But they demonstrate how one class of microbes can rapidly obtain possession of a suitable nutrient media to the exclusion of another class of microbes. From this you will realise the enormous force the sanitarian has at his disposal for the rapid and effectual destruction of waste organic matters, provided that the conditions of the environments of these minute scavengers are

carefully arranged. Fermentation is not necessarily putrefaction. Putrefaction, as we understand it, is an advanced stage of fermentation, and a very bad stage, too, which it is our duty to avoid in all products—be it wine, yeast of bread, cheese; be it sewage, or any other matter.

Thiogenic bacteria play the useful role of converting sulphuretted hydrogen, evolved by putrefaction, into higher sulphur compounds. The process of nitrification is accelerated by light, and the nitrificans *B.* to do their work must have oxygen.

#### SEPTIC TANK.

In the septic tank we have two forms of construction—either one large tank or a tank divided into sections by transverse walls rising more or less in the body of the tank. In the first case, the incoming sewage solids extend throughout the entire tank, part of these settling along the floor of the tank and part rising to the surface of the liquid. According to the period the sewage is in transit before it arrives in the tank, a natural fermentation starts gradually in the sewers, or in the tank itself. This initiative fermentation, if the sewage is further retained, in time gives place to an advanced and second fermentation (putrefaction), hence the name septic tank. This putrefaction not only evolves nauseating and health-poisoning gases, but it also causes the formation of secondary deposits, which no future treatment can decompose. This putrid effluent is hence run on to filters for nitrification.

What happens? The effluent unfit for aerobic life partially suspends the action of the filter, until the foul gas is liberated, and in the meantime vast armies of aerobic organisms are being decimated, and until these have been reproduced the filter cannot regain its full activity. Take a drop of this effluent in the condition it leaves the septic tank and add thereto a few aerobic organisms. An examination under the microscope will persuade the most incredulous. These aerobic organisms die within a few moments. It is not a momentary paralysing, as one might possibly doubt, which would be bad enough, but absolute death, for no amount of added suitable media will restore them to activity. In the higher forms death is more observable, for the collapsing vacuoles of these organisms dilate most visibly, and, rapidly losing their original form, they quivering contract into a ball shape and die. The other form of septic tank has no advantage over the former, but rather the reverse, for the divisional walls form but pockets, in which the organic matter putrifies and silts up, upheaving into the overhead current its secondary formations, which are carried on with the putrid effluent to gradually silt up each crevice in the filter. Nature does not work in leaps, but works