by evolution, and an effluent, before it is suitable to the life in a filter must by evolution, and not revolution, be prepared progressively.

It has been stated in pamphlets by Mr. Martin, of the Septic Tank Company, and others, that by the septic process there is no sludge and no smell. It is right that the author here state that Mr. Donald Cameron, Town Engineer of Exeter, whose name is so well known in connection with the septic tank, was most frank with him on his visit to Exeter in 1905, for not only did he laugh heartily when asked what the steam pumping engine on rails at the Exeter Sewage Works was for, but he candidly admitted that he was much bothered by the quantity of sludge, which he calculated accumulated at the rate of one inch in depth per month on a surface of 175 feet by 38 feet, to 38,000 inhabitants—i.e., 554 cubic feet, equal to 25 cubic inches per person per month, or .8 cubic inches per day. Mr. Dibdin, in a series of examinations on this Exeter system, found, however, that the sewage contained 24.5 grains suspended solid matters per gallon, 13.7 of which remained in the tank, i.e., 3.15 cubic inches per day per individual, at 38,000 inhabitants. The effluent from the tanks was undoubtedly highly charged with secondary formations.

Progress and Disregard of Nature.

Since their inception both tanks and filters have been subject to continual tests and experiments; but while time and money have been expended on costly experiments, sufficient attention has not been given to the requirements of the only too willing legions, who only ask a little consideration to perform the work.

Non-Septic Process.

To assist a natural process, the author has devised a tank with two aims in view. Firstly, to obtain sufficient fermentation, but not more. Secondly, to prepare the fermented effluent by evolution for its nitrification. Fermentation is the name given to the phenomenon of change which takes place in sewage when it is resolved into ammonia, carbonate of ammonia, nitrate of ammonia, methane and carbon-dioxide; i.e., a breaking down of its highly complex nitrogenous and carbonaceous bodies into harmless inorganic compounds. The word fermentation is derived from the French ferver, to boil, and in wine making in France and Italy country people still speak of the grapes boiling, alluding to the noise like boiling caused in the vats by the rising bubbles of carbon-dioxide while fermentation is at its height.

Aero-Anaerobic Process.

In the first chamber of a non-septic aero-anaerobic installation, the fermentation of the organic matter is begun, or, if already begun in the sewers, is carried on to a sufficient degree, B. Coli Communis, amongst others, playing an important part by producing carbonic acid and hydrogen, upon which all anaerobics thrive. This chamber must be of sufficient size to permit the fermentation in the chamber, or in the sewer and chamber combined, to effect the primary disintegration of the solids. The action must not extend further, otherwise the advanced or second fermentation, will set in, therefore a correct size in this tank is of vast importance. To meet the fluctuations which occur in pleasure resorts and elsewhere, longitudinal walls are built, dividing the sections into one, two, four, eight, according to the size of installation. Many still insist that the second and first fermentation are one and the same, and that it is but a playing on words. Biologists who have given special attention to ferment will, however, maintain that there is a second fermentation. Disintegration is carried out by varied families of micro-organisms, and each family of micro-organisms produces its own special effect. Dibdin, who has a profound knowledge in sewage, and some other well known authorities, agree with me that fermentation is not necessarily putrefaction. The following chambers are constructed so as to translate the effluent from the ferment chamber, bringing it repeatedly into contact with the air, where aerobic organisms spore freely in the presence of the oxygen. This action must be carried on sufficiently to prepare the tank effluent for its further treatment on the filter, but this action need not be overdone. Sewage varies very much, but science can now deal with it with certain results. Anaerobic organisms are characterised by inability to grow in the presence of free oxygen. Thus in the translating chambers they are soon reduced to a comatose condition, as fish out of water, and soon become a prey to their powerful enemies, the aerobics-paramoecium, infusorian-rotifere, crustacea, and others. Mr. Dibdin, in his treatise "The Purification of Sewage and Water," has so ably illustrated the influence of these two processes, showing he had paritally proved, and foresaw, the possibility of what to-day the author is endeavouring to introduce, to advance the health and well-being of the community. Let me sum up this point in his own words:—

Aerobies v. Anaerobies.

"The statement has been frequently made that the preliminary breaking down, or 'hydrolysing,' of solid organic matter must first be brought about by the action of the anaerobic organism, whether that action takes place in a bacteria 'bed' or tank, and it has been assumed that this subdivision of the functions of the bacteria in bringing about the purification of sewage was an important and vital discovery. When the point, however, is carefully examined, it appears that, however convenient for supporting a theory, it is not necessarily a fact.

"The fundamental idea which gave birth to this theory was that the whole of the sludge, or matters deposited in a cesspool of a larger or smaller dimension, according to the quantity of sewage to be treated, was converted by the anaerobic bacteria into a liquid condition, and that this continued action afforded a convenient method for entirely destroying the objectionable residue. At first it seemed that this plausible argument has considerable foundation in fact. Tanks were filled with sewage, and a pole thrust down to the bottom, with the result that only a few inches or so of resisting deposit was found. This appeared to be convincing to those whose experience of dealing with large quantities of sludge was limited. 'No resistance, no sludge,' seemed to be the argument. To those who had been accustomed for many years to the sludge question the point was not so certain. For instance, it is well known that sludge containing even less than 90 per cent of moisture can be easily pumped, so liquid is it, and that when such sludge is in a tank or large vessel a pole may be thrust down to the bottom without any material resistance being felt, as the specific gravity of the sludge is only a little more than ordinary water, and about the same as sea water, viz., 1.027, or 2.7 per cent. more than distilled water.

"Hence it is not surprising that the 'pole test' misled many. Time, however, has shown that the anaerobic bacteria only effected the destruction of a certain proportion of the sludge—roughly, about one-half—and that only by producing evil-smelling compounds, which, when the process is carried out in open tanks, has been the cause of considerable nuisance at distances of half a mile or more. On the converse, what has happened when the bacterial process has been carried on in bacteria beds, which, after all, have to be employed to effect the final purification of the foul liquor flowing from the tanks? The preponderating influence of the aerobic bacteria (a few anaerobic doubtless being present in the substance of the organic particles, and thus protected from the air) is such that even when a bed has been overworked the odour from it is entirely inoffensive, even when one is standing upon it, and quite unnoticeable at a short distance.

"The argument that the anaerobic organisms are always necessary for the destruction of the organic debris again falls entirely to the ground when it is considered that when thoroughly broken-up debris is mixed with a sufficient quantity of thoroughly ærated water it is entirely destroyed without the production of offensive gases. Thus, let it be assumed that a quantity of organic debris requiring one grain of oxygen for its complete resolution into harmless forms is distributed, in a fine state of division, throughout five gallons of fully ærated water, which in that case would contain about 1.7 grains of oxygen. In such a condition of things the anaerobic bacteria, which flourish in the absence of oxygen, would be in certainly as distressed a condition as a fish out of water, and hardly capable of exerting very active efforts, whilst the aerobic organisms would be in a very flourishing state indeed; plenty of food, plenty of air, and comfortable surroundings. and away would go the food like magic, without the assistance of the comatose anaerobic organisms, who would doubtless soon himself become a prey to his active and hungry antagonist.

"Anaerobic action (in other words, putrefaction), controlled or not, is an objectionable feature whenever it can be avoided. Under certain restrictions, like most natural functions, it is of considerable value; but its wholesale application in every case is a mistake."

SLUDGE.

Before going to the filter, there is yet an item of much importance, the sludge problem. A considerable portion of the solids disappear by bacterial action, a portion remains in the tank, composed of mineral and organic constituents. The percentage quantity of the organic constituents destroyed by micro-organic action may be briefly followed.

The medium of excretion (fæcis and urine) emitted by a person in the course of a year is 16½ cubic feet, i.e., 78 cubic inches, or 1 1-3 quarts per diem (about 50 ounces), which, taking the daily consumption of water per head at 33 gallons, is 1-100 part. The highest average of organic matter in the sewage of a town with a water system of 33 gallons per head is but three parts to 10,000 gallons, or 2.7 cubic inches per individual. Thus we have the fæcis and urine reduced from the complessive volume of 100 to 3 organic matter, 40 per cent., of which three parts (if ærated) passes from the aerobic tank partly in solution and partly in finely-divided matter in suspension, leaving a daily deposit per person of 1.62 cubic inches. The precipitant in the aerobic tank is, therefore, one part to every 5,555 gallons of sewage which pass through the tank. Half this proportion, however, is generally high, for in most cases one-third has been nearer. To treat this sludge there are two means—one to cut off the sewage from the tank, and after giving the tank a short rest to inoculate with small quantities of fresh sewage. In three to four days a new scum will form, and the sludge which has undergone the necessary action will gradually rise and pass on in finely-divided matter with the effluent to the filter. This disposes in great measure of the sludge, but it has two bad faults. (a) For some days the effluent smells offensively; (b) the effluent destroys for some time all nitrites in the bacterial bed, which only slowly recuperates. The other and better way of disposing of the sludge is that each system, in addition to its effluent filter, should invariably have attacked a small plot of porous soil, or sand filter, for treating its sediment. Thirteen square feet are quite sufficient for 1,000 gallons daily flow. The sediment, or mud, on being brought into contact with the air, gives off a faint odour of tar, not detectable three or four yards from it, which quickly disappears. It dries quickly on filter, and can be removed with a rake. In appearance it resembles garden loam soil, and is quite inoffensive. Where a sludge filter is not practical the sludge can be run to a tank, from which it can be conveniently removed in casks, and sold as manure, having a value of 25 per cent. above guano. The effluent may also be profitably employed for the irrigation of land, from one to two million gallons per acre giving an average increase in grass of 30 tons.

Sewage thus should no longer be understood to be a putrid, foul liquid, for sewage, if well ordered, should not be putrid at all. Sewage at its outfall is absolutely devoid of oxygen gas; and sewage, as the life which ought to abound therein, is very greedy of oxygen, inasmuch as on being mixed with water previously ærated the whole mixture becomes oxygen free. That aeration is desirable, nay, absolutely necessary, is now admitted by high sewage authorities, some of whom until quite recently were still advocates of the septic, or putrid, action. Every tank which receives sewage should be transformed into an aerator. The actual absorption of air takes place only at the very surface of the liquid. Take a pool of stagnant water. Notwithstanding its continual exposure to the air, the water is bad. Give it a little mechanical assistance, and this water will become pure and drinkable. There are two ways of obtaining this result:—

1. By driving oxygen through the liquid at intervals.
2. By displacing the mass, so as to bring gradually the whole volume in contact with the air.

The same applies to sewage. To effect the first, a simple automatic aerator acts admirably. The second requires but an arrangement of partitions across the tank, as you have seen on the plans this evening.

Water has not much capacity for absorbing oxygen, but sewage will absorb at each contact till purified, if given time, as much as four millegrames to every litre, and six to eight such saturations suffice for the fæcis to be decomposed. The aerobic effluent when it leaves the non-septic tank does not annul the action of the first part of the filter, nor prevent the growth of chlorophyll and nitrifying organisms. These, in filters which receive non-septic effluent abound in every crevice, . the chlorophyll being visible to the naked eye all through the filter.

The preparedness of this tank effluent for further treatment can allow of an important reduction in the size of the filter. During the author's last visit to England he saw all the most important installations, and was astonished to observe many most expensive works with one predominating error, viz., area occupied by filters too large, and filters of too fine medium to permit perfect aeration of the filter, which is absolutely necessary; and it is a general case that these filters have to be replaced at enormous expense. Want of air in a filter will produce anaerobic, or putrid, action, and though the effluent appear clear it is bad and putrescible, and will be a nuisance.

Chemicals.

Chemicals in the diluted form in which they arrive from hospitals, etc., have little or no effect upon the microbe action, and beyond the power of precipitating a small part of the organic matter which some chemicals possess they do no further harm. The author has treated hospitals with success, and has never interfered with the daily use of chemicals. Bokesburg Hospital (in Africa), St. John's (in Italy), and others bear testimony.

Storm Water.

In the non-septic system no special provision for dealing with water need be made, as neither the tanks nor the filters suffer by a sudden inrush. Nor can the untreated organic solids be carried forward, while the oxidation of the impurities is facilitated by the increased proportion of free oxygen in the solution. Only when the total volume exceeds four times the dry flow is it advisable to divert it. The non-septic system can be equally well applied to small installations, and calls for no attendance, being self-working. By request of the health office in New Zealand the author applied one such installation to a dry milk and cheese factory at Bunnythorpe, which was giving great cause for complaint. The residents now express their entire satisfaction with the final effluent.

Regularity.

It is not sufficient to have a good effluent from the tank and a well-ærated filter to obtain the best final results. The filter must be worked regularly, for the organisms which do the work must be supplied with plenty of air. Manual labour fails to do this, therefore the filter must have a suitable automatic arrangement, to ensure conveniently regular periods of food and air.

Such a filter can be brought to a high state of efficiency, which condition will be shown by the existence in the filtrate of nitric acid in the form of nitrates. As the process is analogous to that of fermentation, the contact of the micro-organisms with the effluent to be purified must be effected for a greater or less time, according to the purification required. The life of a filter worked in this way is without limit. It is useless waste of time to lay before you the average of purification which can be obtained, for it is apparent that there is no difficulty in obtaining any desired degree of purification by means of a system of treatment on biological lines. What is required is to obtain the standard of purity which will remove all liability to odour, colour and putrefaction, and then construct bacterial beds of sufficient size to meet these requirements. Any increase on this size is an uncalled for expenditure of money. If, in special cases, a higher degree of purity be required, it can be obtained with certainty by the increase of aerobic beds. To obtain a final effluent, equal to that of a septic tank system, the non-septic process demands much less accommodation, and therefore is decidedly preferable; also from an economical point of view.

While at Barking Creek Mr. Dibdin could treat 1,000,000 gallons of sewage per acre per day. The Massachusetts experiments with raw sewage showed that only 60,000 gallons could be continuously treated; so that the effect of suspended solids in the sewage did increase the area required if for filter beds from 1 to 16.6. This area was reduced by Lowcock by pumping air through the sewage to 3.8.

Now, we all agree that an ounce of fact is worth a pound of theory. As these results have been obtained it is perfectly clear that an aerobic effluent, such as can be produced by a "non-septic" aerobic translating tank, will require a vastly smaller bacterial bed to that of a septic tank effluent, which, full of secondary deposits and anaerobic micro-organisms and their gases, is most unfit for the life in the filter bed.

From these results it is evident that the action of a bacteria bed is:—

1. To separate mechanically all particles of suspended matter, and render the effluent clear and bright.
2. To effect the oxidisation of the organic matter in suspension or solution by the agency of living organisms.

It is the establishment and cultivation of these organisms, and the administration of their food in as favourable condition, and with regular and sufficient periods of air, that is to be aimed at in the scientific process of purification by Nature's system.