DISCUSSION ON
PRACTICAL CONSIDERATIONS IN
CONNECTION WITH MODERN
METHODS OF TREATING SEWAGE.

Opened by
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At Provincial Sessional Meeting at Birmingham, September 26th, 1903.

PROF. BOSTOCK HILL:—

THE subject which has been chosen for this, the second sessional meeting of The Sanitary Institute held in the provinces, shows how important the question of sewage disposal is considered to be at the present time, and although we now know so much of the scientific principles underlying the purification of sewage, when we consider the condition of many of our rivers, both in town and country, it is not surprising that the matter should still retain a peculiar interest. The discussion which I hope will arise to-day on the subject is not concerned with the sewage question generally, but with certain practical considerations in connection with modern methods of the treatment of sewage. The old order has changed, and, although it is little more than ten years since the science of bacteriology became paramount among those concerned in the treatment of sewage, practically it may be said that modern methods of sewage treatment have eliminated all the older ones, such as precipitation, with the countless numbers of precipitants urged as desirable at one time or another, and that practically at the present time by modern methods we mean nothing but either treatment on land or by bacterial means.

In considering the subject we must not forget that the great natural

principles underlying the treatment of sewage on land and by artificially made bacteria beds are the same, and that modern systems of sewage treatment have arisen from a proper understanding of Nature's methods in removing waste matters from the soil.

Dealing first of all with the treatment of sewage on land, but few new points of interest have perhaps arisen of late, but I think that in the last few years we have gained certain fresh experience. For instance, we know that land treatment is absolutely useless unless the proper sort of land can be obtained, and not only must the land be proper in character, but also sufficient in quantity. To my mind, one of the greatest advances in dealing with sewage on land which has been made of late years has been the one whereby in many instances (notably on the Tame and Rea Farm, which you will have the advantage of seeing this afternoon) the old idea of preliminary chemical precipitation has been abandoned, and although the sewage sent from Birmingham and some of the other constituent districts is one containing large quantities of acid and chemical waste, at the present time Mr. Watson (the Engineer to the Board) has shown that it is possible to produce an excellent effluent without any of the expenditure and other troubles entailed by the addition of large quantities of lime or other precipitant, which has to be dealt with in addition to the solid matters of the sewage.

This method of treatment, of course, implies two processes preliminary to dealing with the sewage on land, viz., deposition of the detritus and coarser particles, and the provision of tanks for partially liquefying or peptonising the organic solids. This may, I think, be considered a great advance, for not only is there a saving of lime formerly used as a precipitant, but there is a diminished quantity of sludge to be dealt with, and the only extra expense necessitated is the provision of septic or resolving tanks. In many land treatment systems the sludge is treated on the same land. This is a mistake, for as it contains little manurial matter, and in the case of large towns a good deal of chemical matter, it is far better to get it taken away as far as possible and distributed on other lands.

There is no doubt that land, if it can be obtained of proper quality and in sufficient quantity, gives a perfectly good method of dealing with sewage, and excellent results are obtained, as in the case of Coventry at the new Baginton works (vide results), but, on the other hand, in practice great difficulties are met with, and bad results are often obtained, as the various actions in courts of law have shown. One great trouble is storm water, and personally I am of opinion that in many cases where land treatment is used, economy would result from treating the dry-weather flow by bacterial

methods and utilising the land for storm water; the great advantage of this is that the land can be practically returned to agricultural uses. This, however, must be looked upon at the present somewhat in the light of an experiment, especially in the case of towns like Birmingham, where large quantities of acid and chemicals are found in the sewage. As a result of former experience it was believed that the passage of un-neutralised sewage of this type was detrimental to the growth of vegetation, and it was considered necessary, therefore, to add a sufficient precipitant to remove all chemicals and neutralise the acid.

By the septic treatment to which the sewage is now subjected no doubt a considerable amount of iron is removed, and probably the whole of the acid, but whether or not in the long run the treatment will be successful experience only can show.

Coming to a consideration of bacterial methods, it is no exaggeration to say that one thing is now definitely proved, viz., that, properly carried out, and with a due regard to scientific knowledge, these are perfectly valid methods of dealing with sewage in small or large quantities. It will be out of place to take up your time with any elementary reasons for this, and the only points for consideration are the practical ones as to how such methods can be best utilised.

There are several plans of treating sewage bacterially, and unhappily each of us is apt to think that the one we have had experience of, if it has done its work satisfactorily, is the best under all circumstances. But this is not so, and the experience of the last few years has conclusively shown us that systems which will properly and satisfactorily treat the sewage of one district are quite unfitted for the treatment of another class of sewage under other conditions. There are still a few people so enamoured of land-treatment that they profess to ridicule so-called bacterial methods. The septic tank they hold up to ridicule as being nothing but the old cesspit under a modern name. This is perfectly true, and the difference is that in the septic tank and other systems we now utilise and control bacterial action which, in the case of the cesspit or dumbwell, was not understood.

At the present time, I think in practice there may be said to be three methods of working bacterial systems. The first is what is known as the septic tank followed by filtration through contact beds. The second is the use of coarse and fine, or so-called anaërobic and aërobic filters, both contact, while attention has particularly been given of late to the system by means of which we first of all remove suspended matter by chemical precipitation, and then filter through fine aërobic beds, or, as it has been termed, intermittent continuous filtration. Each of these systems has

its advocates. All of them under special conditions are capable of doing excellent work, of purifying sewage to such an extent that the resultant effluents may be discharged as practically non-polluting and non-putrefactive into ordinary streams.

In considering which of them is best adapted for any circumstances, or set of circumstances, we have to bear in mind many important points, notably the quality of the sewage, the surroundings of the works or the proposed works, the available fall in the land, and the stream into which the effluent is finally to pass, and it is only by a consideration of all these points that we can hope to obtain results reasonably satisfactory in all cases.

In many respects, no doubt, the septic tank, or to use a name which I gave it several years ago, and which I think is a better one, the resolving tank, is the simplest to work, particularly if it be adapted to contact beds with automatic supply, and although in many cases simplicity, and therefore smallness of cost, is an important point to bear in mind, it is not the most important in considering this question. The advocates of the resolving tank urge that by it the sludge question is solved, but is this the case? Experiments show that only a proportion of the suspended matter or sludge is removed from the sewage, is in other words digested, and that the whole of the mineral matter and part of the organic matter still remain to be treated. Owing to the very nature of the tank, and the fact that the process carried on is a putrefactive one, the sludge left, particularly in the case of some sewages, is very offensive, and though there may be less to deal with, what there is gives a good deal of trouble and is liable to cause nuisance. A good case in point locally is that of the sewage at Nuneaton. Before the present works (one of the most excellent of its type) were put down, experiments were made as regards the treatment of sewage by resolving tanks, and it was found that owing to the fact that the sewage of the town contains large quantities of albuminous matter coming from the fellmongers' works, both the septic effluent and the sludge were so horribly offensive that the dealing with it was liable to cause considerable nuisance. For small places, however, such as institutions and villages, where the sewage is of a domestic character only, and weak, then, no doubt, the resolving tank is a useful preliminary means of dealing with sewage bacterially.

As regards coarse and fine filters, the main points experience has brought to light are the absolute importance of putting the sewage on to coarse beds as free from inorganic suspended matter as possible. Therefore it is customary now, not only to screen, but to receive the sewage into a detritus tank previous to going on to the bacteria bed. Other points of

importance are that the beds should be of sufficient size, particularly as the capacity of the coarse beds will, owing to various reasons, soon become reduced, probably by some 30 per cent.

In connection with bacterial beds, too, both the nature of the material used and the size of the particles are of great importance. As regards the material, whatever is used should be hard, and in my opinion as smooth as possible. Any material which breaks down is unsuitable. Clinker, if used, must be hard, but of all materials of which up to now I have had experience I prefer granite to any other. Contrary to what one would expect at first, we know now that if the particles of which the coarse bed is made are too large the filter soon becomes blocked, and probably no question at the present time is of more interest to engineers engaged in the work of sewage purification than the one as to what is the best size for these particles.

Another important point is this: that, remove as much detritus as we can, if the coarse bed is used, it must be borne in mind that a time will come when the filtering material will require removing and cleansing, and although in some instances where domestic sewage only is treated the life of the filter may be long, there is every reason to believe that this time will eventually arrive. It is important, too, in my opinion, that the materials used should be washed; otherwise, even in material which looks comparatively clean, a large amount of fine matter will be found which tends to block up the filter beds, and also to wash out into the fine aerobic filter subsequently used. As regards the aerobic or oxidising filter, where the sewage receives its final treatment, and where the aim is to oxidise the innocuous nitrogenous matter left in it, we may have filters of two kinds. The contact bed, where as in the case of the anaerobic bed the liquid is held up in the contact with the particles for a limited period, or what I have previously referred to, the so-called continuous or streaming filter. From a scientific point of view there is no doubt that the continuous, or perhaps it had better be called the intermittent continuous or streaming filter, is the best. Time will not allow me to go into the reasons for this, suffice it to say that I believe that the result of experience up to the present time shows that this is a type of filter which has come to stay. It is only fair, however, to say that there are some difficulties attending its use. It requires more care and observation than the contact bed. It requires to be deeper, and in many places the configuration of the land makes it difficult to obtain the necessary depth; but when it can be obtained, and when it is of sufficient size, then I have not the least doubt that both from a theoretical consideration and on

account of the practical results it is undoubtedly the best. As regards the filtering material, though good results can be obtained with almost any hard material, still I believe that coal (which I was one of the first to introduce to public notice) is still the best. It produces *at once* an effluent far better than any other material, and from the experience that I have had of the Lichfield works now for many years, it continually produces an effluent of high-class quality. Granite chippings are also excellent, and the points which I believe to be of the most importance are that the particles should be hard, angular, fairly smooth, and not liable to break down. Coke breeze, which has perhaps been more used than any other, I do not consider to be particularly good, but it has been shown that excellent results have been obtained from broken stone and also from broken saggars in the potteries, where, of course, they are obtainable practically for nothing.

As regards the size of the particles I believe that, speaking generally, a size of about half an inch, with a few inches of fine material on the top of the filter, gives the most satisfactory results. Another point which has to be borne in mind in the consideration of streaming filters is the distribution. Many of the results hitherto recorded as obtained in this way have been unsatisfactory because of improper distribution, and the loss, therefore, of a considerable area of the filter. This difficulty, at the present time, looks like being overcome by the introduction of the distributor. One of the earliest distributors put down was the one on the coal beds at Lichfield by Mr. Garfield. This is very simple and has exceeded my expectations, because for many years, in winter and summer, it has acted satisfactorily, while the expense has been but small. A somewhat similar arrangement has been put into force at Salford, but travelling distributors of many kinds are now on the market, and where it is possible to use them better results still ought to be obtained.

As to the relative value of different bacterial systems, it is impossible, as I have said, to lay down a definite principle that under all considerations one is better than the others; but providing a very high-class effluent is to be produced, I am convinced in my own mind that the best means known to us at the present time is chemical precipitation first, and subsequent aërobic filtration through fine beds, preferably coal.

In closing these remarks, I feel that I should like to say a word or two on the characters of effluents. Engineers are continually asking for standards of purity to be laid down. It is very difficult to adopt a standard, unless it be a very high one. I consider one of the roughest, but at the same

time best, standards to be applied ordinarily is that of the maintenance of fish life in the pure effluent. It is an object lesson to be appreciated by all, and it shows that good oxidation is being maintained. As regards standards in the form of chemical results, I do not think any hard and fast ones can be laid down. I have seen bad effluents where the chemical results of impurity have been low, while *vice versa* I have seen good effluents where, judging by the ordinary standards of albuminoid ammonia and oxygen absorbed, the effluents would have been condemned. Speaking generally, I think one may say, however, that any effluent sent into a stream should be of such a character that it contains sufficient oxidised nitrogen to prevent it becoming putrescent, and that the general character of the stream, supposing it to be an unpolluted one, will remain unaltered.

In the second Report of the Royal Commission on Sewage Disposal, now sitting, experiments are given dealing with the question of bacterial standards of effluents, and it would almost appear, from some of the views stated that an attempt may be made to require some standard of purification from the bacterial point of view. It has been shown that a chemically purified effluent may contain almost as many micro-organisms as a crude sewage, and it is urged by some of the ultra-bacteriologists that the purification effected, therefore, has been of little value, and that the danger of such a bacterial effluent is almost as great as that of the sewage. If this view be enunciated I do not think that practical experience will bear it out; and I am also convinced that even if it be true, instead of asking local authorities to add to their labour and expense the means for rendering sterile the otherwise purified effluents they send into streams, the proper thing to do will be, as my friend Dr. Reid has previously pointed out, either to go to streams other than those receiving such effluents for water supplies, or else to destroy the disease-producing organisms before they gain access to the sewage. With our present knowledge I look upon any system of sterilizing sewage effluents as impossible, because it must be borne in mind that not only would the ordinary dry-weather flow of sewage be so treated, but that in times of storm it would be equally necessary to sterilize every gallon of storm water, a large proportion of which, under present circumstances, would not and could not go to the sewage works proper at all.

RESULTS OF ANALYSIS OF EFFLUENTS AND RIVER WATER.

Results expressed in Parts per 100,000.

Description.	Total solid impurity.	Free Ammonia.	Organic Ammonia.	Nitrogen as Nitrates and Nitrites.	Oxygen absorbed in four hours.	Chlorine.
Coventry, North Effluent	82	0.528	0.032	1.43	0.432	9.0
" South	84	0.412	0.040	1.32	0.532	9.9
River Avon above Effluents	60	0.016	0.018	Trace	0.232	2.6
" below	60	0.060	0.020	Trace	0.248	2.9
Lichfield, No. 3 Filter	82	0.515	0.040	1.54	0.334	9.4
Secondary Beds, Nuneaton	130	0.901	0.216	1.21	0.97	26.7

J. EDWARD WILLCOX

Dealt first with general principles underlying modern methods of sewage disposal. These general principles being established and understood, it will be conceded that good results must largely depend on overcoming practical difficulties which arise in connection with design and construction of works. Pointed out the impossibility of dealing successfully and economically with all classes of sewage by similar methods regardless of conditions obtaining in each case. First consideration must be volume and character of sewage to be treated and standard of purity required. Explained difficulties in way of fixing standard of purity, though a standard is very desirable from engineering point of view. Requirements of Local Government Board with respect to dealing with six times the dry-weather flow, results of gaugings in various districts extending over long periods showing that this requirement is excessive. Dealt with reason for divergence of volume and also rates of flow, and the effect that area and configuration of districts sewered had on this point and on pollution of streams by storm overflows; also as to how volume and character of sewage is affected by combined or separate systems and trade wastes and the rates of flow, for which provision must be made both for gravitation schemes and pumping schemes, and the effect of varying rates of flow on the design of the tank and filters, giving reasons for conclusions arrived at. Treatment in tanks a necessary preliminary to all methods of treatment. Hints as to the construction of detritus tanks and screening chambers, why over-screening of domestic sewage is undesirable, and means for

removal of silt from chambers. The design of settling tanks and septic tanks, methods of preserving scum if required, and drawing off sludge from septic tanks; over-septicized sewage and excessive accumulations of scum. Illustrations of difficulties met with by reason of excessive scum in septic tank, and offensive nature of septic tank effluent, and the effect upon such effluents when flowing in closed pipes; arrangements for drawing off sludge from septic tanks. General remarks as to land treatment and as to the impracticability of taking a basis of so many persons per acre in considering land-schemes; suggested the basis should be gallons per acre, depending on character of land and nature of sewage. Remarks as to whether the area should be proportionate to the volume dealt with or to the organic impurity in sewage. Dealt with bacteria treatment and pointed out that as the final treatment consists, as is admitted, in aeration and nitrification, this must depend largely upon the intimacy of contact between the sewage and air. Gave reasons why in his opinion percolating filters were to be preferred in many cases to contact beds, and when the latter should be used; the effect of size of particles on contact bed effluents, means of distribution on contact beds, and the advantages and disadvantages of this system. The question of sludging of contact beds, and the materials of which particles should be made; with illustrations of difficulties from using unsuitable materials. The question of distribution on streaming filters, and the difficulties which occur in connection with obtaining even distribution; various types of distributors. Natural means by which contact or filter beds are aerated, and remarks as to varying factors of discharge; air supply, and depth of filters. Power-driven distributors; description of large experiments with electric and power-driven distributors on half-acre filters with various size particles now being carried out by the author at Hanley, in conjunction with Dr. G. Reid, and results obtained therefrom.

THE CHAIRMAN (Dr. Alfred Hill) said that as the time at their disposal was all too little for the object they had in view in discussing this very important subject, his remarks would be very brief indeed. Naturally it came into one's mouth for the first utterance that the meeting was a most important one, and he thought they were indebted to The Sanitary Institute, not only for bringing them together, but for choosing a subject for discussion of such world-wide interest. It was important to their health, to their pockets, and particularly as regarded the command of land on which to treat sewage. To obtain such

land was by no means an easy matter. There might be land available which was unsuitable, or there might be no land available at all. In such case the bacterial system, which they were met there to discuss, came most timely to their assistance. He remembered thirty years ago the condition of their Birmingham sewage-farm. He was consulted in the earliest days of his office as Medical Officer when it was considered necessary to improve the conditions prevailing there. Those conditions were of the most horrible kind. Nothing was done but to run the crude sewage through tanks and then through a little land, where all that chose to subside did so, and the rest passed to the river, while the sludge and detritus had to be taken out, and were collected into a heap, which covered five or six acres of land a couple of yards deep. They might imagine what a nuisance that was. They would to-day see what had been done under the present arrangements; how much the condition of the farm had been improved. They would see much to admire in the manner in which the improvements had been carried out by Mr. Watson. From what he could hear, the Birmingham farm would well bear comparison with any similar installation throughout the country. What struck most people who did not work on the subject was the marvellous discovery that they could, by such simple means, deal with such a problem. There was, however, nothing new under the sun. Nature had been carrying on the process under their noses through all time, but man had not been observant enough to see it. They had not been clever enough to explain why a cesspool should go on being used for years and not get full. The bacterial method had furnished the explanation. They were now trying to imitate nature's own processes, and the farther they could make it natural so much the better.

DR. RIDEAL (London) said the discussion had to deal with practical details, and as they were met in Birmingham and were going to visit the Birmingham works, which were referred to in the printed matter put before them, perhaps the details connected with Birmingham might have some bearing on the two papers presented by Dr. Hill and Mr. Willcox. One was the size of septic tanks. He thought they had a very good object lesson as to what should be the size of septic tanks from the Birmingham experiments. It would be remembered that Mr. Watson, at the last meeting of The Sanitary Institute at Bradford, gave them some figures as to the amount of suspended matter carried over by these septic tanks, and in the paper put in their hands they found the total dry weather volume of the Birmingham sewage was 25,000,000 gallons, and the size of the septic and detritus tanks together were about 12,000,000 gallons, in other words the tank capacity for intercepting the solids was only about half the dry weather flow. The effect of that was to give in the last two years about twenty-four grains of suspended matter in the average liquid which came out of the tanks. Now that quantity was very high indeed. Even in Birmingham, when

there was chemical precipitation, there were only about four or five grains of suspended matters. A good septic tank working should not give more than ten grains. The importance of that was in the matter of distribution, and it would have been exceedingly interesting if in the Birmingham experiments the septic effluent with these high suspended solids had been passed into contact beds, as well as into the continuous filters they were going to see. A septic effluent of this character passed on to contact beds would give them a much greater silting up than was found in other places. Another point was as to the sludging up of septic tanks which had taken place at Birmingham. The tanks now were periodically cleansed, and immediately after this operation the suspended matter in the effluent went down, so that in the last six months' working it had been reduced from twenty-four to fourteen grains. He mentioned those figures because, unfortunately, Mr. Watson, in referring to this matter, did not put it at all clearly at the Bradford meeting. It was clear that by emptying the septic tanks their capacity had been increased, and this had reduced the suspended matter they had to deal with. As to the distribution of the sewage on these continuous filters (a point had been made as to the expensive nature of some of the distributors) he wished to emphasize the fact, that in this connection it was the total cost of the plant, including distribution, which had to be considered. In that outlay the cost of the bed was certainly the largest portion. If they put down £5,000 as the cost of an acre six-foot bed, and £500 as the cost of distribution, they had an additional outlay of 10 per cent. for distribution. But supposing they used a cheap distributor costing only £100, or 2 per cent., it might very easily happen that the total flow through the bed might be 10 per cent. less than in the other case, and thus involve a greater absolute cost in having to provide a larger volume of filter. It was certainly worth while to pay much attention to the method of distribution, and put in a costly if an efficient distributor, if they could get an increase of even a few gallons per square yard per day in the flow through the bed.

DR. REID (Staffordshire County Council) said he was very glad to find that both Dr. Hill and Mr. Willcox thought filtration was better than contact. He thought it was a great mistake that they had ever heard of contact. Had they not heard of contact, by this time efficient means of distribution would have been devised, and efficient filters would have been at work throughout the country. He was afraid they must blame the engineering world for accepting without full examination Mr. Dibdin's suggestion, and for recommending authorities all over the country to lay down contact beds. He was sorry to see they were still laying down contact beds in many places, a policy which he thought they would regret. He quite agreed with Dr. Hill that it was impossible to adopt a method of distribution which would spray a large quantity of septic sewage in the open air in the neighbourhood of towns without causing a nuisance. Any method of

distribution therefore must be by a travelling distributor, so that they would have a small area displayed to the influence of wind instead of a large area carrying the smell a long distance. He also agreed with Dr. Hill that they could not lay down a standard of purity which would be satisfactory all round. They must take into consideration the circumstances of each case and the quality of the sewage to be dealt with. Mr. Willcox had referred to certain work in which the speaker had been associated with him at Hanley. The work of those filters at Hanley had been very instructive. They had as perfect distribution of the sewage over the filters as it was possible to obtain. They had two mechanical distributors, one designed by Mr. Scott Moncrieff, and one by Mr. Willcox, and in both cases they had distributed the sewage as evenly as possible. They had also four sizes of particles in the filters, the total area being half an acre, so that the experiments were on a large scale, and amply sufficient to show clearly the purification which could be effected by works, no matter of what size, with filters composed of different sizes of material. The four sizes of material used for the bodies of the filters in different sections were: three sixteenths of an inch rejected by one eighth of an inch; one quarter of an inch rejected by one eighth of an inch; half an inch rejected by a quarter of an inch; and two and a half inches rejected by one inch. As a matter of fact the results obtained by the fine grain filters were practically identical. The percentage of purification on the organic ammonia basis being 95 per cent., 93 per cent., and 93 per cent. in the case of particles of three sixteenths of an inch, one eighth of an inch, and a quarter of an inch. The corresponding figures of oxygen absorbed in four hours at 80° F. was 90 per cent., 90 per cent., and 91 per cent. The results from the larger sizes, although excellent, were not so good as in the case of the smaller sizes, the figures being 91 per cent. in the one case, and 86 per cent. in the other. The nitric nitrogen was 1·86, 1·61, and 1·75 per 100,000 in the case of the smaller sizes, and 1·59 in the larger sizes. They were the results of nine analyses in each case, and these included the results obtained in the first instances before the beds were properly ripe. If he had only taken the later results the nitric nitrogen figures would have been higher. In the case of the larger particles that was the only instance with which they had any trouble from obstruction. The experiments showed, he thought, that the proper and best size of material was a quarter of an inch and that there was no need to put a smaller size material in the filters. In Staffordshire they had been using a smaller size even than one eighth of an inch; but these experiments proved that they need not go down to such fine grain material. The depth of the filters was 4 ft. 9 in. to 5 ft.; he thought 5 ft. was the proper depth. It was needless for him to say that he fully endorsed Dr. Hill's remarks as to the work of the Royal Commission on Sewage Disposal, and the impossible suggestion that by any process sewage could be converted into drinking water.

DR. FOSBROKE (Worcestershire C.C.) said there were two points raised in the papers upon which he would like to express an opinion. That opinion was the result of 780 analyses made by the direction and at the cost of the Worcestershire County Council, who had laid down at Malvern and Oldbury a series of tanks, viz. (1) septic tanks with continuous filtration, (2) contact beds with streaming filters, and (3) upward flow tanks with streaming filters. There had been four different kinds of material used in connection with each set of tanks: coal, coke, bricks, and local stone. Shortly, the results of the experiments had been this: the septic tank with continuous filtration had given the best effluent, and the contact beds had not reached the high standard of purification which was once expected. Personally, he shared the opinion that the contact system was dead or, if not dead, was dying. He thought that coke was the best material that could be used. He could not agree with Dr. Hill that coal was the best. He also thought that for streaming filters the sizes of material described by Dr. Reid gave the best results. They also experimented with the effluents upon fish, using trout, and he was convinced that it was more a matter of aëration than anything else. Their experiments showed that extremely fine filtering media were not necessary, and that septic action with continuous filtration was better than contact.

MR. SIDNEY R. LOWCOCK (Westminster and Birmingham), said that as his name had been associated with the filtration of sewage for a good many years, he had better refer first to the treatment of the tank effluent on filters. As long ago as 1890 he started experiments on the filtration of sewage, and he would like to read them the conclusions he then arrived at, and which he expressed in a paper on "The Filtration of Sewage," which he contributed to the Institution of Civil Engineers. "(1) That filtration is not only a mechanical but also a chemical and biological process when it is properly carried out, and when sufficient aeration is provided for; (2) That no practicable chemical process yet devised will, alone, do more than remove the suspended matters in sewage, and a very small portion of the dissolved impurities; (3) That dissolved impurities can only be removed by the action of micro-organisms, *i.e.*, by nitrification, and this can only be effected subsequently to the decomposition of the organic matter and the formation of ammonia, and in the absence of undecomposed organic matter; (4) That organic matter cannot be destroyed or converted into plant food until it has been dissolved; (5) That as nitrification proceeds far more rapidly in a moistened and aerated porous soil than in a liquid, and as the nitrifying powers of soil are capable of cultivation, the process should be carried on by means of filtration, so that the organisms can be cultivated and supplied with food in the filter; (6) That the most important factor in the processes of decomposition and nitrification, and the subsequent preservation of the nitrates formed, is an ample supply of air; (7) That the suspended matters in sewage

should not be allowed to pass on to the land or filter-bed as they clog the surface, and have to remain until they are decomposed before they can be destroyed. It is therefore evident that whether the organic matter in sewage be first deposited in the form of sludge and subsequently applied to the land, or be dissolved and passed on to the land as effluent from the tanks, the same process has ultimately to be carried out; and it must be a question of convenience and cost as to whether it is better to precipitate the organic matter in suspension and transport it to some place where it can be made use of or thrown away, or to endeavour to dissolve the whole of the organic matter in suspension and treat it in the effluent water so as to produce nitrates." Those were the conclusions he arrived at in 1890, and they were as true now as they were then. He was extremely glad to find that both the gentlemen who started the discussion, and those who had taken part in it, were all coming round to his way of thinking, that filters were a great deal better than contact beds. At that time he thought that it would be possible to work the filters continuously, but he had long since come to the conclusion that he was wrong. They could not work them continuously; they must work them intermittently, and he was very strongly of the opinion that the final treatment of the effluent should be, by means of intermittent bacterial filters on to the surface of which the liquid is sprinkled, as nearly as possible in the form of rain. He thought a good deal of confusion had arisen in the nomenclature of the three systems of bacteria beds used for sewage or tank effluent treatment. He would suggest that beds similar to those in use at Sutton should be known as "contact beds," and the other two systems in which the sewage or effluent is distributed over the surface intermittently or continuously, and allowed to trickle downwards through the filter, the outlet from which is always open to the air, should be known as "intermittent bacterial filters" and "continuous bacterial filters" respectively. Dr. Fosbrooke had already alluded to the experiments carried on at Malvern. He would like to add one or two remarks, as he was called into consultation by the Worcestershire County Council, and had prepared the designs and specifications for these works. There was one point in connection with the experiments which he wished specially to emphasize, that was, that the sewage was taken from the main sewer to each of the systems through V-shaped notches, the apex of each being on a level with the invert of the sewer. The proportions of the notches were such that the flow of sewage to each system was proportionate at all times to the flow in the main sewer, so that the systems were worked under really practical conditions, both as to the quantity and quality of sewage dealt with, and not taking a small regular quantity only, as was so often the case in experiments. That was a very important point. As regarded the thickness of the filtering media and the size of the particles, they were practically the same as at Hanley. He entirely agreed with all Dr. Hill had said with only one exception, that was, when he referred to the use of automatic machinery on a sewage disposal works. He did not believe it was possible to have automatic

machinery that would work satisfactorily under all the varying conditions. They had both the quality and the quantity of the sewage continually varying. Take the means which were often adopted with the intention of making the distribution of storm water automatic as an instance: The Local Government Board required provision for treating three times the dry weather volume as if it was all sewage proper, then a further three volumes must receive a modified treatment, and all beyond that can be turned into the river. A very common arrangement was to put in a fixed weir at the side of the main sewer, so that all sewage coming down up to the rate of six times the mean flow would go on to the sewage works, while all above this rate of flow would pass over the weir direct to the stream. Then a second weir was constructed lower down, so that the sewage up to the rate of three times the mean flow went on to the sewage tanks, and the balance up to the rate of six times was diverted to the storm water area. If rain came at the time of minimum sewage flow (when the sewage was frequently only tap leakage and infiltration water) the whole of it went into the works and was treated as sewage, though the greater portion of it would only be storm water; but if the rain came down at the time of maximum sewage flow, then a considerable portion of the whole flow went direct into the river, and the first flush at any rate was as bad as crude sewage. That was one difficulty; the other was that for long periods the storm water area got no sewage at all, and consequently was not in a state of bacterial cultivation, and was not in a condition to do its work when necessity arose. The point he wanted to make was that such weirs could only deal automatically with rates of flow and not with volumes. They could not, therefore, be automatic, but must be under the control of the man in charge. This was of course only another instance of the well-established fact that the whole secret of the success or failure of sewage disposal depended upon intelligent, constant, scientific supervision and control.

MR. J. S. PICKERING (Cheltenham) said he would like to refer to the question of the material for the beds. He quite agreed with what the previous speaker had said, that the material should be as hard as possible. He had had a fair experience with various kinds of material on a large scale, and he had come to the conclusion that it was a mistake to employ coke or any material which was likely to disintegrate. He was sure that where coke was adopted there would be a difficulty in the silting up of the beds. With regard to the question of flow, he was very glad to hear what Mr. Willcox had said. He had endeavoured to explain that the quantity of sewage to be treated was not six volumes the dry weather flow per day, but at the rate of six volumes. It would seem rather extravagant to lay down works for treating six times the dry weather flow, and he did not think that was the intention of the Local Government Board. The works should be laid down in order to treat storm water which comes down

occasionally at the rate of six volumes a day, and as Mr. Willcox had said, it was rarely that six times the dry weather flow came down the sewers for twenty-four hours together. Mr. Willcox had asked whether any of those present, and who were to speak in the discussion, had any experience of the Dortmund tank. He understood that these tanks were about to be constructed and used at the Birmingham works, and he believed they would be a great success. His experience was that the Dortmund tanks were very useful indeed; he had experienced no difficulty in taking out the deposit from the tanks, but he thought that in large works like Birmingham it might be found desirable to have a small engine and pump for pumping into the delivery-pipes of the tanks for the purpose of stirring up the mud and deposit on the bottom before extracting it from the tank. He found by so pumping into the Dortmund tank that it need not be cleansed of the deposited matter for three or four weeks. There was another advantage of pumping occasionally into the tank, that it stirred up the deposit and allowed a great deal of organic matter to go through, as he thought there was such a thing as extracting too much of the organic matter. He thought if engineers and others would give particulars of their failures as well as of their successes, they would render a service by showing what to avoid. In the bacterial scheme he devised he had open channels between the septic tanks and the filters, and he had to close them because of the nuisance, and he thought that would be found necessary in the case of all septic tank effluents. He knew that with all manufacturing sewage there was a great nuisance from the septic tank effluent, and there would always be a difficulty in avoiding the nuisance in distributing the sewage over the bed, whether by percolation or otherwise. He did not see how they were to remedy that at present. He would like to bear out what Mr. Lowcock had said as to how unnecessary it was to have automatic gear. The work of emptying the beds could be better performed by intelligent labour.

COLONEL JONES, V.C. (War Office Sewage Farm at Aldershot), said that with regard to what Mr. Pickering had just pointed out, he agreed that the whole success of these contact beds or streaming filters (which seemed to be the most popular term at the present moment) the whole success or failure depended upon the character of the liquid sent forward from the septic tank. If the liquid from the septic tank contained much suspended matter it would choke up the contact beds or filters, and every effort must therefore be made to keep back the suspended matter in the septic tank if they wished to have a life for the filter bed. Suspended matter might be of two kinds: organic and inorganic. In his opinion it was not right to retain from entry into septic tanks anything but inorganic matter, because no microbes had a taste for anything of the mineral kingdom. In many cases, however, it was usual to keep out everything that could be screened, whether mineral or organic matter.

Mr. Lowcock had omitted one point when he went back to his old teaching. In that early teaching he (Mr. Lowcock) proposed to aerate the filter by forced draught, which had never been properly worked out. He would like to know more about it, and hear of more experiments in the way of mechanical aeration of filters and its results. Mr. Lowcock appeared to have given up the idea himself. The great object, to his mind, was to get aeration. He did not believe in mechanical methods because he did not know anything of them; but he knew that the success of sewage treatment was dependent very much upon the access of air naturally. He might say he had been at the subject of sewage treatment for the last thirty-five years, more or less, and he, like Mr. Lowcock, might congratulate them on coming in the end to his idea of land treatment. His original dominant idea in those early times was "the separate system." The fights he had in those days to demonstrate the necessity of keeping the rain water from the sewers must be recollected by many present at this meeting. It was impossible to deal with sewage effectually unless they knew what they were going to get to treat within reasonable limits of variation, and since about the year 1885 engineers had generally admitted that his contention was right.

MR. A. J. MARTIN (Westminster) said he had listened with a great deal of pleasure to these two papers, but he must admit he was taken a little aback at the list of points which Mr. Willcox hoped would receive full discussion in the very short time at their disposal. There was one point raised by Dr. Hill upon which he would like to say a word, that was as to the supposed offensive character of the liquid and sludge from a septic tank. He would remind them of a remark made by Mr. Watson in his valuable paper on "The Purification of Sewage," recently published in the *Contract Journal*. Mr. Watson there stated that "at a great sewage works, nuisance invariably followed pumping, churning, brushing and cleaning operations of all kinds"; but that "where the works were in a quiescent state there was almost an entire absence of smell." Nuisance was thus largely a matter of the way in which works were handled. Then with regard to the sludge. One reason why septic sludge had been found so offensive was the practice of having small tanks and removing from them large quantities of material only partially digested and in an active state of putrescence. If they had their tanks large enough to bring about the full decomposition of which the organic matter was susceptible, they would get a residuum considerably less in volume and which could be dealt with without any nuisance. In reference to the sludging up of filters, he disagreed with Colonel Jones as to the impropriety of removing organic suspended matter from the tank effluent on its way to the filter. For the last eight years they had made a point of freeing the effluent as far as possible from suspended matter. This point had not as a rule received the attention which it deserved. He was therefore glad to hear of the arrangements described in Mr. Watson's paper for removing

humus from the tank effluent. The discussion had been largely devoted to the question of the best mode of distribution. He was saddened to hear Dr. Fosbrooke say that the contact bed was dead, or if not actually dead, that it was dying. He recollected that four or five years ago it was said that the septic tank was dead or dying; it was not dead yet; as a matter of fact it was in a very healthy state of convalescence, and he predicted that four or five years hence the contact bed would be in an equally healthy state. They had heard that day of the difficulties attending a proper system of distribution to a trickling filter. The practical merit of Mr. Dibdin's invention of the contact bed was that they got a perfect distribution. Every cubic inch of space received a cubic inch of water, and in due course, when the filter was emptied, a cubic inch of air. Then with regard to the superior chemical results claimed to be obtained by the trickling method, many of which were quoted in Mr. Watson's paper, one reason why the results from the contact system were not as a rule as good as they should be was the prevalent system of working without due regard to the character of the sewage. It was formerly usual to allow two hours for filling, two hours for contact, two hours for discharging, and two hours for aeration. Two hours for aeration of the bed was far too little. If they allowed two hours in all for filling, contact, and discharging, and left the remaining six hours for aeration they would get results far superior to those which had hitherto been obtained. In the installation laid down from his firm's design at Leeds, consisting of two septic tanks and a single set of beds, a purification was effected of 91 per cent. in respect of oxygen absorbed and 86 per cent. in albuminoid ammonia. Such results as these were generally considered unattainable by septic tanks and single contact. Their attainment at Leeds was in great measure due to the cycle of working adopted and the precision secured by the use of automatic gear. He entirely agreed with Dr. Rideal that it was true economy to spend money on an efficient distributing apparatus. It was a mistake to lay down ten or twenty acres of beds and then stint the sum spent on the apparatus for working them. He must totally dissent from Mr. Pickering's remark that the chief use of automatic apparatus was to save two or three labourers' wages. That was not the reason they used it. The reason why automatic apparatus should be used was, that a reliable and efficient gear like that at Leeds or Exeter would give them results which could not be obtained by manual regulation. By the use of automatic machinery they got the work done with absolute certainty and with due regard to the flow at the time. It was for this reason, and because of the results achieved, that he was of opinion that automatic machinery should be used in connection with bacteria beds.

MR. SCOTT-MONCRIEFF (London) said, at the recent Congress at Brussels, foreign gentlemen of great scientific distinction gave their views, and said

"they fully admitted that the natural treatment of sewage—sewage farming—was capable of yielding the best results." He quoted from the *Contract Journal*, in the issue of 23rd Sept., page 697, and he presumed that Dr. Rideal agreed with them. This found expression in the conclusions submitted by Dr. Dunbar, and he understood it was included in a resolution which was unanimously accepted. Now, if it got about in England that the best expert opinion, both here and on the Continent, considered land treatment the best way of dealing with sewage, the public might reasonably be astonished that they should be asked to spend enormous sums of money on less obvious methods.

DR. RIDEAL (interposing) said he was at the meeting at Brussels, and there was no such resolution passed.

MR. SCOTT-MONCRIEFF said he was indebted to the press for the information, and he was very sorry indeed that in this case he had been misled. But even if Dr. Rideal was correct, the Local Government Board did agree: so there was ground for his saying an opinion existed that land was the proper method of treatment. With this Colonel Jones cordially agreed. All he had to say was that theoretically that might be perfectly true, but nevertheless the majority of experts in this country now held the opinion that nine-tenths of the land in England was unsuitable for carrying it out. There were two main difficulties—the difficulty of getting land at all, and the still greater difficulty of obtaining suitable land. The question then came to be that if suitable land was not available, could they so concentrate the methods of nature that the solution of the problem could be carried out completely upon very limited areas. In the object-lesson they were going to see that afternoon, the extreme difficulty of treating sewage upon land was fully in evidence, and they would also find in Mr. Watson a responsible public servant who was confronted with this difficulty in an accentuated form. He was now devoting his attention to concentrating the methods of nature in the method now known as the bacterial treatment of sewage, and they might congratulate themselves on now having an opportunity of seeing this object-lesson on an extensive and important scale. It was impossible to exaggerate the value of this object-lesson. They would see land purchased at an enormous cost, and laid out at heavy expense, presenting difficulties which were admitted to be insuperable. They would be shown a fine arrangement of tanks in which anaerobic fermentation was going on. Further on they would see Mr. Watson's effort to solve the second part, the nitrifying half, of the problem. It was hardly necessary at this time of day to seriously consider the question of contact beds. The process was in no sense of the term scientific. The organisms must be looked at from the point of view of their life processes, and how to maintain them in a state of maximum efficiency. They had much in common with other forms of life, and he made up his mind long ago that they

had to be fed with known and regulated quantities of food and at regular intervals. It must be recognised that they were no more capable of absorbing excessive quantities of food than creatures in higher stages of development. Contact beds never have been and never can be arranged so as to provide optimum conditions for the final mineralisation of organic nitrogen. The necessary factors are the best rate of discharge, the best period between each discharge, the best supply of air, and the necessary depth of filter. He had designed a testing apparatus that could be seen at work that afternoon which enabled these four factors to be determined accurately for any given sewage, and also a distributing machine capable of delivering 500,000 gallons per twenty-four hours which could be adjusted so as to give effect to the results obtained from the testing apparatus, both as regards rate of flow and the periods of rest required between each discharge. He was far from wishing anyone to suppose that what he had done was final or incapable of improvement, but he was quite convinced that the line he had taken was the only one that could insure the final solution of the sewage problem in which purification in its best sense was combined with the preservation of the mineralised organic matter in an effluent which is a perfect plant food.

MR. F. B. O'SHAUGHNESSY (Birmingham) said, that from a somewhat varied experience, he was most strongly in favour of septic treatment as a preliminary operation in sewage works. One point in Dr. Hill's paper he would like to refer to, and that was the question of coal as a medium for bacteria beds. Some of the very first experiments he conducted on coming to Birmingham were with respect to the behaviour of this sewage in contact beds. Several of these beds were filled with coal, and the effluent from the coal was so good that on the first occasion of filling the effluent came out clear, sparkling and without odour, so much so that the men who worked the beds drank a quantity of this effluent. The difference between the effluent from the coal and that from the other beds was enormously in favour of the coal. With regard to land treatment, people used this term as if it implied one set of conditions only. As a matter of fact, effluents from different kinds of soil vary greatly, depending on the nature of the soil or subsoils. Even in Birmingham, where their land was of an exceptionally good quality, speaking in general terms, they had certain fields which would never give a satisfactory effluent. The cause appeared to be the presence of excessive proportions of ferrous iron in the subsoil of those fields. Each field ought really to receive special treatment, and required as careful supervision as an ordinary bacteria bed, if a thoroughly satisfactory effluent was desired.

DR. BARWISE (Derbyshire County Council) did not think a too vigorous protest had been made against any recommendation of the Royal Commission that sewage effluents should be bacteriologically treated, because it was generally

understood that the Royal Commission had some idea of setting up a bacterial standard of purification. It was not the duty of a sanitary authority to turn its sewage into a drinking water, but the duty of water authorities to take their supplies from unimpeachable sources. He would also like to add the weight of anything he could say in criticism of the large amount of suspended matter in the effluent from the septic tanks at Birmingham. He could not help thinking that they would be well advised in increasing the storage in their septic tanks, so as to further liquefaction before putting the septic tank effluent on the filters. They had been trying slag from iron works in his county, and he would like to warn any engineers who might be about to put down filters that this was a very dangerous material to use. It contained a large amount of carbonate of lime, which was soluble in the effluent from septic tanks. He had seen filters made of this material rapidly break down. Another point was in reference to distribution by revolving pipe distributors; the holes might be calculated mathematically to distribute the right amount of liquid per hole, but when a pipe was swirling round centrifugal action came into play, and no man could calculate the effect of centrifugal force upon a revolving pipe moving with varying velocities so that it would deliver the same quantity of sewage per square yard at different distances from the centre. Each pipe would have to be set by actually testing it, not by theoretical calculations. With Mr. Scott Moncrieff's revolving arm it could be done, and they would see it done at the Birmingham works. In conclusion, he would again like to protest against the idea of sewage effluents being so purified that sanitary authorities would have to turn such effluents into a bacterially innocuous fluid.