SEWAGE DISPOSAL.

PAPER

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By J. T. Noble Anderson (Past President).

Sewage, meaning the liquid material which issues from two or more domiciles, and for which by statute the Public Health Authority is responsible, is a most difficult thing to dispose of. According to the decency of its disposal, one might well gauge the civilisation of the community. The civilisation of ancient Rome was swamped by the wave of barbaric invasion, with the result that the excellent laws compelling cleanliness of living and the ample water treatment of sewage disappeared from the world. Unfortunately, Christianity, revolting against the depression of the rigid Imperial rule, condemned sanitation, and made a fetish of bodily uncleanness. Hence we have it that over the larger part of Europe to-day sanitation is so little heeded, that the annual deaths from preventable diseases are only comparable with a continuous state of war.

No one aspect of sanitation is more important than this matter of "Sewage Disposal." This, so far as the municipality is concerned, as already mentioned, starts from the point of reception into the public sewer of the drainage from each individual tenement. The main problem is to properly treat the human and animal excrements. This is no easy task, but the disposal of trade wastes is an equally difficult matter, and often they, too, have to go into the public sewers. Much of the subsequent trouble is due to the antagonism to natural biological processes of these materials. The journey of the human effluents, both liquid and solid, should be accomplished from the very start till the anaerobic processes have done their liquifying work with as little disturbance as possible.

Some preaeration before sedimentation seems to be the best way to prevent putrefaction, but in no case should the sewage be hurried on to its ultimate disposal before it has had a sufficiently long, undisturbed water treatment for the enzymes to do the work of breaking up the solid excreta. In many systems it has been usual to precede this by a liquifaction tank, which may or may not be accompanied by screening arrangements.

As the whole subject is still in a very controversial stage, the author proposes to emphasise his own view by a brief recital of the facts on which it has been evolved. His earliest experience, apart from his University and apprentice work, was to be employed first on a County Towns sewerage system, and subsequently on the sewerage of the City of Belfast. Coming in 1890 to Melbourne, when the late Mr. Mansergh's scheme was being debated, he was honoured by the first chief engineer to
the Melbourne and Metropolitan Board of Works, the late Mr. William Thwaites, by many consultations, and the one matter which caused most discussion was that he thought the grades adopted in the Melbourne system too steep. He contended that the flatter grades he was accustomed to, where the system dealt with the combined sewage and drainage, should amply suffice for what was to be a practically separate system. At this stage sewerage works were going on elsewhere in Australasia, which he visited. In Sydney somewhat similar grades were used to the metropolitan grades here, while in Christchurch, New Zealand, a separate system, the grades were flatter than those in the older world. The latter were both mainly hydrolytic, preparatory to purification for irrigation. Consequently, when some years after the author was entrusted with the draining and sewerage of Dunedin, where he allowed storm water equal to 550 per cent. in excess of the maximum flow to enter the sewers, he found the Christchurch system so much superior in the character of the effluent to either of the other places, that he unhesitatingly adopted its main features for Dunedin, where the sewerage outlets were all to the ocean. In particular, he took the Christchurch grades for the branch sewers. For the main interceptor, six feet in diameter, he took the gradients from similar London grades. Then where a portion of the system had to be treated on the same separate system with back yard storm water admitted as in Melbourne, he used Dortmund tanks to treat any effluent which might occur at relief points on the sewers during excessive rain storms. This was so successful that he made the whole of the sewage from the main intercepting sewer discharge into two large detritus settling basins working alternately, with the object of always securing a rest period of not less than six hours, before the sewage reached the pumps. This meant that liquification was practically complete, no rank or offensive smell is noticeable, and the gratings were spaced ¼ in. apart. The odour was of the tarry nature which is now associated with sewage where putrefaction has been avoided. Prior to this solid sewage had often accumulated in the main sewers of the city, with the result that on more than one occasion careless workmen had to be rescued from the burning gases, and treated for burns in the hospital.

A contributory factor to this satisfactory result of the new work was that the last 3000 feet of the main sewer was left with practically no gas vents, and the backing up of the water during the six to ten hour periods of rest, when the detritus tanks were filling, gave the opportunity for the slow travelling of pure air back from the outlet into the sewer, which, being undisturbed by the
eruptive evolution of the gases of putrefaction, continues the same natural biochemical changes as go on in a river protected from violent winds, where sewage rapidly becomes innocuous.

The chief point in preventing putrefaction seems to be to have the sewers so designed that they will never be so shallow that the solid matter will be allowed to decompose in the air. And the good results obtained by the egg-shaped sewers must surely be due to this feature, since, in them, a much smaller flow gave a greater depth. In the case of Dunedin, the author did not rely on the result he expected to achieve, and consequently made extensive investigations, and arranged for an alternative discharge at a headland three miles distant from the point originally marked off. This was done lest the beautiful ocean beach might be polluted by such a foul effluent as had defiled Belfast Harbour, and made the vicinity of the outlet at Wellington, New Zealand, unapproachable. In consequence of the alternative not having ultimately been required the municipality was saved an expenditure of over £30,000—which he had lead it to anticipate.

On this question of flatter gradients he ventures to recommend as follows: Never estimate to exceed a velocity when half full of three feet a second in a branch sewer, nor 2/4 feet a second in a main sewer. Discussing this matter on his return to Melbourne many years after, Mr. Thwaites stated that had he to redesign the Melbourne system he, too, would have used flatter gradients. Generally speaking, any extra cost in the larger mains is balanced by the shallower depths.

As to calculations, he has not correlated the old “Kutter” tables with more modern formulae, but the easiest way to give a guide is that the co-efficient for rugosity “n” in Kutter’s formula should be increased about .001 above what would apply for similar pipes carrying pure, cold water. In tests at Dunedin for drains between four feet and six feet diameter “n” should have been .0105, but worked out at .0115.

The author is strongly of opinion that the system so often adopted of controlling ventilation by flap valves in the main interceptors was wrong, and has never introduced any such artificial expedient. All outfalls and settlement tanks should be protected from strong winds.

This brief narrative of the reason for the adoption of the Sediment Tank type of treatment at Dunedin does not complete all to be said about the collection of sewage and the transport to its place of final treatment, either by aeration and spreading over soil, or dilution with water. Of course, it must always be recollected that every municipality presents a fresh
problem. In the case of Dunedin, the sewage to be dealt with being on the almost completely combined system, will during the winter be made more difficult to purify than the Melbourne and Metropolitan Board’s. In the summer there will probably be little or no difference between the two places.

No more instructive example on this question of variation in conditions can be quoted than that of Cairo, Egypt. Of Cairo, we have two almost classic descriptions of the works. The first is from the original designer, Chas. Carkeet James (see “Proceedings Institution of Civil Engineers,” London, vol. 202, 1916). The second gives the history of its failures and successes by one of the engineers who extended and improved the system (“Proceedings of Institution of Civil Engineers,” vol. 231, 1931). It is thus when failures are frankly and openly acknowledged and discussed by friendly criticism that a real stepping stone to future success is gained. Here the point is very plain, that a concentrated sewage, where the daily discharge is only eleven gallons per head, requires different materials and a different treatment from British and American practice.

Here, too, some insight is given into the justification of the old time flat-bottomed “Cloacae,” because in Cairo the necessity to continually clear the main sewer by manual labour required a more secure foothold for the workers than could be got with modern standard circular or egg-shaped sewers. While the different habits of Easterns is explained, it is, however, rather regrettable that the different physical characteristics of the faecal matter was not also mentioned, because gas-producing qualities in this have a very real effect on the time and duration of the liquifying processes. Incidentally, it may be here mentioned that the old practice of treating offensive sewage with chloride of lime has recently been re-established, and proved to have no detrimental effect on the subsequent treatment or sludge production, nor an appreciable effect on the pH value of the sludge.

As will be gathered, the author does not consider that the compressed air systems have been unqualified successes. The cause is not far to seek. Development of any proprietary system, whether patented or otherwise, does not give the same opportunity for disinterested investigation. This is not in any way a stricture on the honesty or want of skill of the promoters. Neither the originators of the Shone Air system, nor the Exeter Septic Tank system, could have been accused of putting their financial success before their duty to give the public their best possible service. Both of them died poor men. However paren-
tal feeling intensifies the bias which it is inevitable for each designer to have in his own creation, and consequently, unless he is unusually free from prejudice, and gifted with not only unusually liberal views and freedom from bias, his work does not get the impartial try out which is so essential to success. To each new process the utmost sympathy is due from the users, remembering that while one acknowledged success will indicate its possibilities, at the same time to establish a success, it is necessary to try out the process by Nature's own method, trial and failure, and that better lessons are generally to be learnt from failures than from successes. Thus, when one promoter of compressed air quoted the brilliant success made by it at Buenos Ayres, he forgot that it was in the hands of an unusually clever engineer, the late Clere Parsons, and that the final effluent went to the second largest fresh water stream in the whole world. At Buenos Ayres the engineering world, beyond the adoption of the 'Stereophagus,' learnt little from that great scheme, whereas in this Cairo scheme the abridgment of the Shone system shows in a very valuable way its limitations. But the Air system adopted in Buenos Ayres was not the Shone system, and the raising of the bulk of the sewage by the Stereophagus, a centrifugal type of pump, by ensuring the breaking up of the faecal matter, probably contributed to the happy results. While it was acknowledged that the compressed air system, giving an overall mechanical efficiency of less than 40 per cent., was from economical considerations inferior to a gravitation to a single station as in Melbourne, still, on a balance of interest on capital against annual working expenses, Buenos Ayres showed a very big economy in the comparison, a matter which the author proposes to comment on later. Forty years ago, there were only two main systems of sewage disposal, namely, by land irrigation, or by discharge into a relatively large body of water. In either case some previous treatment was required. For irrigation it was generally assumed that screening sufficed, while in the discharge into smaller rivers, such as the Clyde, where the dry weather discharge did not exceed the statutory limit, chemical treatment was resorted to. By the beginning of the present century, however, modern hydrolytic biological methods were beginning to be studied, and even then there was a movement to substitute B.O.D. tests for the rule of thumb 6 to 1 standard.

Before, however, making any comments on the modern methods of treating sewage, this question of the design of sewage reticulation and main conduits cannot be left without a few remarks on the author's experience on that very vital question,
“materials.” Up to quite recently no British engineer departed from the very safe rule of glazed earthenware pipes, well vitrified, and glazed brick linings in the larger masonry conduits. Consequently, the late William Thwaites took a very bold stand in only putting a single glazed block in the inverts of his concrete mains. Owing to the adverse experience of sewage on concrete in Berlin, the author, while going a step further in abandoning the glazed invert block, after communicating with the engineering chemist who had done the most thorough work on this subject, the late M. Jules Feret, of Paris, adopted a richer concrete, and took steps to ensure its imperviousness by frequent absorption tests, and as a prevention of sulphate damage kept the lime ratio below 60 per cent. For this he had to import the cement, using chiefly Commonwealth cement manufactured in Sydney. In only three places was any deterioration of the concrete discovered during the four years of the author’s control, and from correspondence with the Dunedin City Council, twenty years after, he learnt that no further cases had been discovered.

As in the more recent paper on the Cairo Sewerage (Pinson on Cairo Main Drainage Extensions), the trouble with concrete is discussed at so late a date as 2nd December, 1930, and does not throw much light on the question, hence some further explanation of Dunedin’s immunity is called for. The reason for the author’s extreme attention to the detail will be seen in the records of the Thirlmere Aqueduct, Manchester, of which he had a personal acquaintance. The first occasion where trouble occurred was at the St. Claire drainage outlet, where the polluted water first met the ocean. Here the cement mortar in the concrete simply flowed out as a white, milky liquid, with occasional inky streaks, and contained sulphates of lime and magnesia. The depth to which this occurred was over an inch in a couple of weeks. The wooden shuttering was replaced on the uninjured portion, while the damaged portions, only a few square yards, were plastered over with an even more impervious mortar, and protected by a wooden shield, with the result that when the wave action about three years after removed the wooden shutters, the concrete was absolutely sound. No further trouble was experienced at the subsequently constructed outlets where the wooden shuttering was left undisturbed.

Of the other two cases, one was in a reinforced concrete pipe, which was replaced, and for which no reason could be assigned other than that mentioned above, too green, having been put into the work within a month. The third case was due to a local cement having a lime content of 65 per cent. As these results were obtained over three miles of interceptor, several miles of branch drains, and nearly two acres of walls and floors
exposed to sewage, it is obvious that all concrete requires to be made safe for sewage is to be made impervious to more than two per cent. by weight of water, and to be well seasoned before being exposed. Of course, all the pipes less than 12 inches in diameter were of glazed stoneware, and great difficulty was experienced until the brickyards adopted methods which gave a reasonable (½ in. diameter) tolerance when properly vitrified. Never since then has the author experienced any of the troubles which are usually associated with either of these materials. He is anxious at present to have an opportunity of testing the newer types which are now coming on the market, and which may not require so much supervision on the part of the engineer.

The other materials which he banned were steel and wrought iron, and that in particular for the rising mains from the centrifugal pumps to the outfall aqueduct. Here, owing to the agitation of pumping and high speed, he anticipated great trouble, and as two three-feet diameter cast iron pipes, nearly three quarters of a mile long, would have been too expensive, he used built-up wooden pipes. These were regarded by his Board as being too temporary an expedient, and they were replaced soon after he had left New Zealand by one 3 ft. 6 in. steel main. This, however, failed in about ten years, when luckily the staff had retained the timber, which they rebuilt as a single 3 ft. 6 in. pipe. The cause for the alteration from two 3 ft. pipes to one 3 ft. 6 in. pipe was that, as explained above, the original fear that if the ocean beach should be polluted, all dry weather flow sewage should be pumped to a more remote outlet to which the higher level 3 ft. main would discharge. The absolutely inoffensive nature of the discharge enabled this precaution to be abandoned, and also works estimated at £30,000, bringing this stronger sewage to the further beach to be indefinitely postponed. Hence the substitution of one rising main in place of two. With these two exceptions, nothing unusual was adopted so far as materials were concerned. But as marking the step away from the septic tank treatment, some other experiments made at that time, 30 years ago, have an historic interest, and their narrative will enable how the present more economical methods of sewage treatment have been evolved to be seen. Prior to constructing the two large sedimentation tanks mentioned above, the author made a Dortmund tank, that being the modest predecessor of the present day Imhoff tank. This was to take the drainage from about 12 acres of land being reclaimed alongside the harbour foreshore, beside the debouchement of "The Water of Leith," at which it discharged. This area was to be subsequently sewered on the
separate system. There were two circular tanks, 25 feet diameter, sunk on c.i. cutting kerbs into the slurry and running sand for which the volcanic material of the port is notorious. They were to pass up to six cusecs, with an automatic by-pass to meet extreme floods. One of the heaviest floods on record occurred in October, 1905, before the reclamation works were quite complete, and, as the detritus tank had been too small, very heavy road metal and gravel found its way into the tanks, which were so expensive to clear out that the storm water was passed by the by-pass. However as an experiment, these tanks were invaluable, and justified the large provision made on the main sewer. Also during the twelve months that they were kept working they showed excellent results in clarification, which was tested after every flood.

Simultaneously with the use of these Dortmund tanks which, as in Dunedin, were used as double detritus tanks rather than as sedimentation tanks, in England the experiments were being carried out which inaugurated the double-decked tank treatment system. The largest and earliest successful installation was at Birmingham. That system is now best known as the Imhoff or Emshcer tank system. The British form takes a much shallower depth, and the movement of the water being chiefly in a horizontal direction, in place of vertical, as in the Dortmund, it has been found economical to make it rectangular on the plan. The Germans still adhere to a circular plan. The treatment of sewerage is now almost stereotyped in four distinct stages:

1st.—Separation of the heavier solids by a detritus tank. In small separate sewage systems this stage is sometimes omitted. The principle on which it acts is similar to the settling tank described in the author’s paper on “Water Purification.”

2nd.—Screening and Sedimentation. In small separate systems the septic tank is still much used, but the double deck type mentioned above seems to be far the most popular, and as now designed enables the sludge to be removed for subsequent treatment much better than was possible with its predecessors.

3rd.—Treatment of the effluent so that it can be safely discharged into the natural water channels.

4th.—Treatment and disposal of the sludge and wastes detained in all the previous mechanisms.

Many forms of these mechanisms will be well known, and luckily none have so far succeeded in having been so standardised as to hinder advancement. A closer study of this subject is valuable,
as giving a very useful lesson on the extreme caution which must be adopted in accepting established practice, and working to standards, because in almost every case, when a new departure is proclaimed to be established, the most unexpected difficulties are experienced, and the cautious rule of the medical profession, to not consider any new claims as established until at least five hundred successful treatments have been authenticated by careful, disinterested and competent observers, stands.

At the present time the most promising system of treatment has grown out of the double sedimentation tank, and is known as the activated sludge treatment, whereby the old processes, which took days and months respectively to produce an entirely innocuous sludge and a quite anaerobic fluid, is hastened so that in two to four hours and a couple of days respectively the whole process is successfully achieved. This is usually accompanied by a certain amount of pre-aeration, but the essential part of the system depends on the mixing of the matured liquids and the seeded sludges with the raw sewage, and some fresh sludges returned to the inlet.

At first assumed as only applicable in large towns, where the great saving in area by a plant which, passing the sewage through it at a speed never less than double the old rate, was, of course, so much smaller, has since been so cheapened that it has now become likely to be used almost universally.

Rate of Progress and Acknowledgment of Failures.

An excellent example of how the profession can learn most rapidly when engineers are induced to give a full account of their failures and efforts to correct those failures has recently been given by the Department of Sewage Disposal of the New Jersey Experimental Station (1929-30). These and former reports deal very fully with this new system of oxidation of sediment tank effluents, and of the treatment and disposal of sludge, showing how failures have generally arisen from the neglect of such rudimentary precautions, as efficient screening and the need to remove flocculent matter and keep down the quantity of scum, also to regulate the pH values and so prevent foaming and excessive gas formation. Since the publication of such results, no engineer should be excused who repeats the errors which were made by these American pioneer efforts. Every allowance must be made for any engineer introducing a new system into a new country, provided he acts intelligently and with diligence, but there should be a tribunal such as this institution to pillory those who are so careless or stupid as to repeat mistakes which have been already discovered and widely published. The author has on more than one occasion advocated that Australia should have an automatic scientific Court
of Inquest, independent of bureaucratic control, to deal with all such cases, and to bring to light the cause of all failures in engineering work. Without the knowledge gleaned from such as this, the lessons they should teach are largely lost to the world.

To return to treatment of sewage itself, in machinery great advances have been made in pumps for unscreened sewage, and the replacement of labour, and constant care by automatic devices. Great attention is now given to the preparation of sewage before entering the sedimentation tanks. All that will not create a nuisance, and is calculated to complicate and make subsequent treatment slower and more expensive should be removed in the straining stage. Scraping and skimming are the most troublesome of these operations. For seating a quarter of the other total volume of sewage in the form of sludge is often drawn off and returned to the inlet after being thoroughly cleaned and sieved. Observance of such precautions, coupled with such improvements as the activated sludge system, not only assures a better and more uniform purification, but by such means a great saving is effected as compared with treating the whole quantities. It is by the employment of such devices that the overwhelming cost of sewerage works can be reduced, and only by a close consideration to the details of each case can the promoters of sewerage schemes satisfy the hard-headed citizens that they can give value. Treated sewage can never be profitably used except where there is an unusually good area for a sewerage farm and close to a profitable market.

A great deal can be done to cheapen sludge disposal. The gases from the sediment beds are collected and burnt, establishing temperatures of over 80 deg., so that all the processes are hastened at very little cost. So far efforts to make profit from sewage disposal have seldom succeeded. And works of sanitation must be looked on as profitable in that, like tree planting, the profit to the community in health and happiness is the only immediate benefit. But the ultimate indirect benefit in greater efficiency and longer life to the masses can, however, be gauged by the fact that it is mainly due to sanitation opening the congested areas to pure air, and the decreased B.O.D. of the potable waters, that the average duration of human life has been increased since the middle of the last century by fifteen years. And the half has not yet been done. The time is not far distant when we will have among us as recognised tradesmen the sewage plant attendant, who will be as well versed in all the cultures which he must seed and grow, and those which he must destroy, as is the farmer or gardener in the handling of his rotational crops, and in the eradicating of noxious weeds. Then every country town will have as sweet a water and pure air as
are enjoyed to-day on the farms, and the large cities will be more wholesome than the villages.

This paper has been given as a companion to that on "Water Purification," the two subjects being inextricably connected. And did time permit, no subject would be more profitable than a discussion on the forms of life, both microscopic and easily seen and handled, which can be taken as red lights or green for the users of all natural waters.
DISCUSSION

The President said that it had been stated in the paper on "Water Purification" that when pathogenic bacteria were taken down to a depth of twenty feet, they were destroyed. He presumed that the destruction was due to the combination of pressure and light being favourable to the existence of other organisms which devoured them, for, if pressure alone were sufficient, they would be destroyed in the pipes. With reference to bacterial treatment of sewage, he wondered whether by the careful selection of appropriate bacteria they might secure more rapid or more perfect treatment, just as in other fermentation industries, where the quality of the product was secured by such discriminative selection. Mr. Anderson had referred to methods for ensuring against rapid deterioration of concrete sewers. Could he enlighten us on the condition of the old Roman sewers of puzzolana concrete? It was unfortunate, as the author had pointed out, that sewage farms were not feasible in every neighbourhood owing to unsuitability of soil, for then the cost had to be borne entirely by the ratepayers. Would it in such cases in Victoria be payable to cart the sludge and sell it for a fertiliser? He would like to express his appreciation of the remarks of Mr. Neylon, who emphasised the seriousness of silting of reservoirs, which was a double calamity, for it destroyed a great public work and at the same time was symptomatic of the even more serious loss of valuable surface soil due to improper methods of working the soil or haphazard deforestation.

Mr. A. C. Mitchell, in expressing his appreciation of the paper, said it was of special value at the present moment when many country towns were waking up to the necessity of sewage. The selection of any particular system must depend on local conditions, and he stressed strongly the need for the consultant, who was a specialist, to be called in to prevent inappropriate methods being adopted.

Mr. A. E. Hughes said he appreciated the paper, and would like to read it before discussing it. Referring to Mr. Neylon's remarks, he said that most engineers were diffident about criticising the work of fellow practitioners, as Mr. Neylon had suggested was done in France.

Mr. Wm. C. Rowe said he greatly appreciated Mr. Anderson's paper on "Water Purification," which he had read and re-read. With regard to the washing of the sand used in filtration, what was the nature of the contents of the wash water?
Were the bacteria killed, or were they still in a deleterious state? If so, what became of the wash water?

Mr. Anderson, in his interim reply, said the most mischievous bacteria were all destroyed by others that reside in sludge. The question of siltation of reservoirs was most important. He recalled one flood which deposited eight inches of silt on over 80 acres at Canberra. Mr. W. B. Griffin had attempted to overcome the trouble in the Molonglo basin by afforestation. Recent issues of London and American Institutions of Engineers showed that siltation was causing great trouble not only in dams, but in rivers also. Gold washing is going to be the cause of trouble to the Hume Weir. Erosion and silt were dangers not only to the reservoir, but to the country itself. Only one other thing could come near it for destruction. That was the forest fire, which works hand in hand with it.
Mr. C. M. Neylon contributed:

Mr. Anderson has raised so many questions bearing on the health and welfare of those in country towns, that I should like to read a few notes on points I did not cover in the few impromptu remarks I made at the last meeting. A big difficulty in our northern towns is the quantity of water required for gardens, lucerne patches, and the like. In extreme cases it amounts to nearly two hundred gallons per head daily in summer. Country water trusts are composed largely of business men on whose premises there is a high valuation. Consuming relatively little water themselves, they naturally object to paying increased rates for filtering water for the wholesale use of residents with large gardens and lower valuations. The late Mr. Tobias Kelly, when engineer for the Cobram Waterworks Trust, installed a rather ingenious scheme, which overcame this difficulty, by a separate low pressure service, with reduced pumping costs and cheaper pipes. The rating was to be equitably distributed by means of low pressure meters. I understand the scheme worked well, although I have not seen it in operation. In the case of towns where the drinking supply is filtered or where pure, high pressure water is brought a long distance at considerable cost, there is no reason why cheaper water could not, with appropriate safeguards, be used for a separate low pressure service for watering gardens, flushing sewers and channels, the irrigation of vegetables for market in hot weather, and the like.

Perhaps as necessary as the treatment of water is the pasteurisation of milk in hot weather. To avoid impairing its dietetic value, this must be done at a carefully regulated temperature, while to deal effectively with either the tubercle bacillus or the bacteria causing diarrhoea, it must be carried out in closed receptacles, i.e., under pressure.

A matter closely affecting many of our country water supplies is the siltation of reservoirs. Already these contain quantities of silt. Investigations in America have shown cases with more than sixty per cent. of the capacity silted in little more than a decade. Mr. Elwood Mead pointed out that these troubles can only be averted by proper investigation, control, and replanting of catchments, from the inception of the work. For want of geological knowledge also, reservoirs have been constructed which would not fill until water was diverted into them.
Mr. J. T. Noble Anderson, in reply:

Mr. V. G. Anderson's contribution comes first for attention. From his wide experience, his pessimism as to the early hope for purification of our rivers must be given attention. Certainly in so wholesome a climate as we have, it is no easy matter to persuade the people of the necessity for pure water. With respect of our rivers, and the towns situated on their banks, it would seem that the fastidious nature of the Melbourne city dweller has raised the sensitiveness of their country neighbours, so that the work of purifying sewage is likely to precede the purification of drinking water—though both should undoubtedly go hand in hand. There is a very big tendency to overestimate the efficacy of chemical treatment, both for sewage and for water purification. In most cases some chemical treatment is economical and advantageous.

With regard to Mr. Neylon's remarks in reference to chlorination, after sulphate of copper, this is undoubtedly the cheapest method of sterilisation. Unfortunately, there are two drawbacks. First, a completely sterilised water is not only unwholesome, but the palate soon turns. Consequently, though it removes the disagreeable smells and tastes due to certain pathogenic germs, and makes the water safe from practically all the dangerous pathogenic life, still, without an opportunity for the water to recover its organic life constituents, it is not good practice to deliver it direct into the town mains, and consequently a large clear-water basin becomes a necessity. After the chlorination, the water should be filtered, to remove the corpses, and also to oxygenate it. The almost universal British practice is to use the gravity sand filter, which has the sand bed efficiently aerated, and between the period of rest in the sand filter, and in the clear-water basin, sufficient time must elapse for the restoration of a sufficient organic population to render the water wholesome and palatable. In summer, in these latitudes, this should not take longer than two days; in winter, luckily, when the temperature makes the regeneration slower, the water consumption will also be slower, and consequently it will only be necessary to provide for summer needs, a total capacity of two days' hot weather demand.

The bacteriologists stress the necessity to avoid any contamination of the purified water in the clear-water basin, and a common practice is to cover this in, which practice may be sound in certain cases where water contains such objectionable faecal matter as coli com., and where anaerobic treatment would be needed, as in a septic tank liquifying sewage. However, it is wholly at variance with a rational treatment of pure water, aerated, and requiring insolation to stimulate the growth of
wholesome life. One objection raised against the sunlight is that it encourages the growth of chlorophyl and algae. These need not become sufficiently plentiful if two precautions are taken. First, the clear-water basin must be at least fifteen feet deep, so that there may be a sufficient turn over of the water for the bacteriological life which inhabits the lower regions to circulate in to the shallower at least once every twenty-four hours, with the diurnal temperature cycle, and so consume those lighter inhabitants of the surface. And the worst feature does not give much trouble in the deeper basin. Here a longer period elapses before the sedimental refuse need be removed, before it breeds the more objectionable forms of life. And, compared with a shallow basin, the cost of cleansing is insignificant. The second objection is that the open basin is subject to contamination from all the winds that blow, and in the vicinity of a town this is very obviously a serious danger. To minimise this danger, the author adopts the expedient of surrounding the clear-water basin by the filters and settlement tanks, where the untreated water will get the full benefit of all the dust. And, except in the case of a very strong north windy day, little contamination is likely to occur. Even then it is inconsistent to expect the clear-water basin to be more carefully protected than the elevated tank, which, generally situated in the middle of the town, is almost universally in Australian towns left uncovered. If the clear-water basin is situated, as is usually the case, in a secluded reserve near a public park, it is superfluous to be more exacting about it than the service tank.

It is seldom appreciated in Australia that except in large industrial centres, where the circumstances are peculiarly suitable to the “rapid” process, the gravity filter is still preferred, and when chemicals can be saved, this proves much cheaper in annual costs, while in a new country it will almost always be found cheaper also in first cost. In many circumstances it is uneconomical to sink the bed level of the clear-water basin below the water table, making this much shallower than is desirable. Except for the periodical cleansing, this should never be drawn off below the full 15 feet depth.

Referring to the question, How is the wash-water from the filters disposed of? care must be taken that the drains through which the unavoidable ultimate wastes are discharged into natural watercourses may be free from objectionably noticeable foreign matter. As already mentioned, in the British regulations this is taken as meaning that the polluted water must not represent more than one-seventh part of the total volume of the existing dry weather discharge of the watercourse. This is an ideal unattainable in Australia, where so many watercourses
run dry so often. However, this system is rapidly being replaced by more scientific requirements, and, if necessary, the washwater should be discharged on to cultivated land or otherwise rendered innocuous for discharge into the ordinary storm-water drains.

In reply to Dr. Fitzpatrick, so far the direct use of electric rays to sterilise water has proved too expensive for general use. Practically the same thing, ionisation, is best obtained by chemical treatment. The treatment which seems most promising to-day is with carbon. Activated carbon can give very efficient sterilisation at a low cost.

Returning to water purification, the algae and green scum trouble is not so serious as it seems. If the silicon contents are kept low, these should not give unpleasant tastes and smells, and the excessively crystal clear waters are to be looked on with far more suspicion than waters with the slight discolouration which comes from these vegetable growths, because the clearness may be present owing to such nitrates as do their work in the dark, and make spring waters so attractive in appearance. Thanks to their comparative darkness, the effluent from septic tanks is often so crystal clear that it is drunk without misgivings.

The author is very grateful for the compliment paid by several speakers in having read the paper so closely.

The President suggested that Mr. Anderson might present in the coming year another paper giving further details of modern trends in water purification and sewage disposal.
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