gain, as has been proved in the case of London. Briefly, a good chemical process will do about one-half of the work of purification; and in many cases it is not necessary to go further. With regard to the kind of chemical to use, lime, either alone or in conjunction with aluminium sulphate or with ferrous sulphate, is most frequently employed. When the resulting sewage sludge has to be filter-pressed, lime is almost essential for the primary treatment of the sewage, in order to destroy the glutinous nature of the sludge. In the case of large towns like London, Manchester and Salford, the sludge is shipped in specially designed steamers, of 600 tons to 1000 tons burden, and discharged into the sea at a distance from the coast. The London outfall works have a fleet of six steamers, which convey the sludge out to Barrow Deep, a channel in the North Sea about 10 m. east of the Nore lightship. Each vessel has four oblong tanks having a total capacity of 1000 tons of sludge, which can be discharged in seven minutes when the valves are fully opened. The sludge is discharged about 10 ft. under the water and being agitated by the action of the ship’s screws is very completely diffused. The sand and earthy matters soon subside and the organic matter is rapidly consumed by the organic life in the sea-water. A careful microscopical examination and chemical analysis failed to detect more than the merest trace of the mineral portion of the sludge, either in dredgings from the bottom of the channels or on the surface of the sandbanks. The cost of the disposal works out at about 4⅛d. per ton of sludge.

In the case of towns situated on rivers above the range of tidal waters, the further purification is effected either on land, or by means of artificial filters, or a combination of the two. The question of land treatment is frequently considered from the standpoint of so many persons to the acre; but the best method is to ascertain how many gallons per day an acre of land will purify. As the quality of land varies greatly, the proper volume to be applied per acre can only be ascertained after a good deal of experience. The range lies between about 3000 gallons per acre per day in the case of poor land, to about 3o,0oo gallons in the same period in the case of the best. Let us assume an instance of the latter kind. The works have been designed on a basis of 1000 persons per acre, producing 30,000 gallons of sewage per day; the land being of a highly suitable character, and the sewage having been clarified, success is assured. But, conversely, through faulty construction of the sewers, the sewage amounts, say, to 6o gallons per head; the land, unable to deal with the liquid, quickly becomes water-logged and offensive, and the works are a failure. Precisely the same remarks apply to artificial filters, which are always designed upon the basis of so many gallons per square yard of filtering material. Many failures of both land and filters have been due to the fact that the actual sewage flow was greatly in excess of the original estimates. We may say that clay soils lie at one end of the scale, and very porous sands or gravels at the other; obviously, therefore, each case must be considered on its merits. It should be remembered that when such moderate quantities as 30oo gallons per acre per day are applied to land, there is no necessity to remove the suspended matter; broad irrigation being resorted to, the land readily assimilates the solids, and thus one source of expense may be eliminated.

The artificial filters are now generally called bacteria beds; although filters have been in constant use in some cases, as for instance at Wimbledon, for a great number of years. The first filters constructed at these works were made in 1876, and were about 70oo sq. yds. in extent. With the growth of popula- tion additions have been made of at least five times that area. One of the original beds was used for crude sewage, but the mineral matter choked it completely, and experience pointed to the necessity of clarifying the sewage before filtration. Whether the treatment should be in open or in closed tanks, or whether chemicals should be added, has been much debated; but seeing that ordinary sewage contains one ton of suspended mineral matter in each million gallons, it is clear that if this is not removed before filtration, it will be retained in the filters and ultimately choke them, as happened at Wimbledon. The

common cesspool has been resuscitated and improved under the name of a septic tank. In this the disintegration of the suspended matter is brought about by anaerobic organisms, and the liquid in passing slowly through the tank absorbs most of the gases due to the breaking down of the organic matter. There is no oxidation at this stage. The liquid is next passed through artificial filters, of which there are many types. What is known as a “ contact ” filter was constructed, probably for the first time on a large scale, at the London (Barking) works. The object sought to be attained was that of making each cubic yard of filtering material perform the same amount of work, and the least expensive way was apparently to close the outlet, and charge the filter with liquid, allowing it to remain in contact for about two hours, and then drawing it off so that the bed could be thoroughly aerated. No doubt a better way would be to distribute the sewage in the form of a shower of liquid, and work the beds continuously, but this involves a good deal of expense for spreading appliances, and a fall is necessary in the works, which is not always obtainable. Probably the most complete installation of the kind last referred to is that at Salford. Iron pipes are led over the surface of the filters, and spraying nozzles are placed at short intervals, so that the sewage is apph\*ed in the form of a heavy shower. But whatever form the filters and appliances may assume, the final result is the same. If the beds are properly aerated, the aerobic organism establishes itself in prodigious numbers, and attacks the organic matter, breaking it down into harmless, soluble and gaseous products. It is, of course, assumed that the filters are adequate in area, and are properly managed. With regard to the materials to be employed in making sewage filters, it is now well established that the size of the particles has a more important bearing than their composition. At the same time, it may be remarked that materials with very rough surfaces, as for instance coke breeze, are more effective than those with smooth surfaces. Doubtless the former classes afford, in the interstices, a lodging for the bacteria, and no doubt a given quantity of material with rough surfaces will harbour greater numbers than the same amount of smooth.

A reference must be made to the Manchester experiments. The experts’ report suggested the provision of 60 acres of filters for dealing with the sewage of the city, which is said to average 30 million gallons per day in dry weather. But after inquiry into the merits of the proposal the officials of the Local Government Board recommended that the filters should be 92 acres in extent, and that the effluent should be finished on land. Storm water filters to take the excess after the sewage was diluted six times were also recommended, such filters being designed to pass 500 gallons per sq. yd. per diem. In this case clarified sewage was to be dealt with on filters 3 ft. 4 in. in depth, composed of clinkers broken to pass a sieve with meshes of 1½ in., but retained on one with meshes of ⅛ in. It will be observed, therefore, that the bacterial treatment of sewage has scarcely as yet emerged from the experimental stage, but it will certainly be adopted in many cases where it is impracticable to obtain good land in sufficient quantity for the purification of the sewage. With regard to the disposal of sewage-sludge in inland towns, until it has been fairly established by a long trial that bacteria will dispose of this material, the reduction of its bulk by means of filter-presses will he found to be the most satisfactory method of dealing with it. The practical effect is the conversion of 5 tons of offensive mud into 1 ton of hard cake, which may be readily handled and carted. The cost is usually about 2s. 6d. per ton of cake, and a million gallons of average sewage produce about 8 tons.

The chief works of reference upon this subject are:—Colonel E. C. S. Moore, *Sanitary Engineering;* L. Parkes and H. Kenwood, *Hygiene and Public Health·,* A. J. Martin, *The Sewage Problem·,* A. P. Poley, *Law Affecting Sewers and Drains·,* J. J. Cosgrove, *Principles and Practice of Plumbing, The Purification of Sewage;* Colonel E. C. S. Moore, *New Tables for the Complete Solution of Ganguillet and Kutter's Formula for the Flow of Liquid in Open Channels, Pipes, Sewers and Conduits·,* W. J. Dibden, *The Purifica­tion of Sewage and Water;* W. Spinks, *House Drainage Manual·,* S. Rideal, *Sewage and the Bacterial Purification of Sewage. Municipal Engineers' Specification.* (J. Bτ.)