The water-carriage system of sewerage will bo noticed here under its three aspects:—(1) the ultimate disposal of sewage ; (2) the system of common sewers by which sewage is conveyed to its destination ; (3) the domestic arrangements for the collection of sewage.

I. The Ultimate Disposal of Water-carried Sew­age.—In the water-carriage system of sewerage the fertiliz­ing elements are so largely diluted that it becomes a matter of the utmost difficulty to turn them to profitable account. It has been estimated that every ton of London sewage contains ingredients whose value as manure is rather more than 2d., @@1 a value which, could it be realized, would make the sewage of the metropolis worth a million and three quarters sterling per annum. Sewage farming, however, does not pay. After much costly experiment the conviction is gaining ground that, neither by applying sewage directly to land, nor by any process of chemical treatment that has yet been proposed, can sewage be made to yield a return as manure which will cover the cost of its transport, treatment, and distribution, except perhaps in a few cases where the circumstances are peculiarly favourable. At the same time, sewage farming does afford one satis­factory solution of the problem of how to dispose of sewage without creating a nuisance—a problem in which any question of profit or loss is of secondary importance. A very early instance of irrigation by sewage is that of the Craigentinny Meadows, a sandy tract of 400 acres, on which part of the sewage of Edinburgh has been dis­charged during certain seasons for nearly a century. There, owing to favourable conditions, and to the fact that complete purification of the sewage is not attempted, the process yields a profit ; but no such result could be looked for if the sea were not at hand to receive the imperfectly cleansed sewage and the wholly uncleansed surplus. Germany furnishes a still older example of irrigation in the sewage farm of the town of Bunzlau, which has been in existence for more than three hundred years.

Five methods of treating sewage may be named, of which two or more are often found in combination.

*Discharge into the Sea* or into a large watercourse is in general the least costly means by which a community can rid itself of its sewage. Much care in the choice of outlets is necessary to make this plan effective in avoiding nuisance. Some towns make use of tanks or outlet sowers of large capacity, from which the discharge is allowed to occur only when the tide is ebbing. When the volume of sewage is very large, even this precaution does not wholly pro­tect the neighbouring coast from foul deposits. A striking instance is furnished by the case of London, which discharges its sewage into the tidal estuary of the Thames at Barking and Crossness during only some three or four hours from the time of each high tide. It is found that the discharged matter is washed up and down the river with every tide, occasionally reaching as far up as Teddington, and that the portion which is not deposited in the form of mud banks only very slowly works its way to the sea.

*Broad Irrigation.—*By this is meant the use of sewage to irrigate a comparatively large tract of cultivated land, in the proportion of about 1 acre (or more) of land to every 120 persons in the sewage- contributing population. This system is now largely and success­fully used, especially where the soil is a porous sandy loam. Fears that the farms would prove dangerous to the health of the neighbour­ing district, and that the crops and vegetables grown on them would be unwholesome, have proved groundless. When the farm is properly laid out and carefully managed the effluent water is pure enough to be admitted to a clear stream from which water-supply is drawn. Broad irrigation is practised at Croydon, Cheltenham, Blackburn, and many other English towns ; and it has recently been applied, on a very large scale, to dispose of the sewage of Berlin.

*Intermittent Downward Filtration.—*This is another mode of purifying sewage by applying it to land, which differs from broad irrigation in requiring a much smaller area in proportion to the sewage dealt with. In 1870 Dr Frankland @@2 drew attention to the fact that if sewage were passed through porous soil, not continu­ously but at intervals long enough to let the soil become aerated, rapid purification took place through the oxidizing action of the

@@@1 Hoffmann and Witt, *Report to the Government Referees on Metropolitan Drainage,* 1857.

*@@@s Report of the Rivers Pollution Commissioners,* 1870.

air which the soil held in its pores. He estimated that an acre of suitable ground, well furnished with subsoil drains to remove the water after percolation, could in this way take the sewage of 2000 persons. This estimate is now considered excessive, and 1000 persons to the acre is a more recent limit. Mr J. Bailey- Denton at once took up Dr Frankland’s suggestion, and in his hands the system of intermittent filtration through land has been successfully applied to the sewage of many towns. @@3 The land which constitutes the filter is used to grow vegetables and other crops. Clay soils are, as far as possible, avoided, and the land is thoroughly underdrained at a depth of about 6 feet. The sewage is distributed over the surface in open channels, the proper laying out of which is an important item in the cost of the system, but is essen­tial to its success. When the number of persons exceeds 500 per acre it is advisable to precipitate the solid matter that is held in sus­pension before the liquid is applied to the land, in order to prevent the surface of the ground from becoming clogged with sewage sludge. Mr Bailey-Denton has pointed out the advantage which the system of intermittent filtration offers as a supplement to broad irrigation, where that is carried out. A serious objection to the disposal of sewago by irrigation is the fact that the farmer must take the sewage always,—at times when it hurts the land as well as at times when the land wants it. But by laying out a portion of the land as a filter bed the sewage may bo thrown on that whenever its presence on the remainder would do harm rather than good. Mr Denton has applied this combined system in several instances, and insists, apparently with much reason, that such a combination offers a better prospect of profit than any other efficient mode of purifying sewage. The system of intermittent filtration through land has been recommended by the Royal Commission of 1882-84 as a mode of treating Loudon sewage.

*Filtration through Artificial Filters* of sand, gravel, ashes, char­coal, coke, peat, &c., though often experimented on, can scarcely be described as an actual system. It is attended by the difficulty that the filter becomes speedily choked by the deposit of sludge. The intermittent use of a suitable artificial filter will, however, servo efficiently to oxidize and therefore purify the liquid portion of sewage from which the sludge has been previously precipitated and filtration through coke is used in some instances as a supple­ment to the process which is next to be described.

*Chemical Treatment, or Precipitation.—*When sewage is allowed to stand, or to flow very slowly through a large tank, a gradual subsidence of the solid particles takes place. The subsidence is, however, much too slow to be complete before decomposition sets in. But it may be very greatly accelerated by the addition of certain reagents, with the object of producing a precipitate which, in fall­ing, will carry down with it the minute particles of solid matter that are suspended throughout the mass. Lime is the substance most usually employed. It is introduced in the form of milk of lime, and in the proportion of about one ton of lime to one million gallons of sewage. When thoroughly mixed, the liquid is left at rest, and a rapid separation of the sewage follows, into a compara­tively clear supernatant liquid and a glutinous precipitate or “sludge.” The sludge has little value as manure, for the best agricultural constituents of sewage are contained in solution, and very little of the soluble matter is carried down in the deposit. The sludge is dried by being strained over beds of slag, pressed into blocks for transport, and got rid of by being burnt or dug into the ground or thrown into the sea. It has been used in the manufacture of bricks and of cement (Scott’s process), but in general it can be disposed of only at a loss. The clarified effluent still con­tains dissolved organic matter, and may be admitted into running streams only when a high standard of purity is not compulsory. When, however, the volume of the running water which it enters is relatively very large a quick purification takes place by means of the oxygen which the water carries in solution.

The lime process is practised, without further purification of the effluent water, at Leeds and at Burnley. At Bradford, after precipitation by lime, the effluent is filtered through beds of coke- breeze. At Birmingham the sewage of 600,000 people, after clari­fication by lime (which also serves to neutralize the acid contri­buted by manufactories), is used to irrigate a farm of 1200 acres.

Very many patents have been obtained for the precipitation of sewage by other chemicals in place of or in addition to lime. In Hillé's process lime is the chief ingredient, with tar and chloride of magnesium or calcium added. At Coventry the precipitants are sulphate of alumina, protosulphate of iron, and lime, and the effluent is afterwards filtered through land, in the proportion of 1 acre to 5000 of the population.

Sillar’s “ABC” process, worked by the Native Guano Com­pany at Aylesbury, differs from others in producing a sludge which has considerable value as manure. An emulsion of clay and carbon with a little blood is first mixed with the sewage ; a precipitating solution of alum is then added, and the mixture

@@@3 J. Bailey-Denton, *Intermittent Downward Filtration, with notes on the Practice and Results of Sewage Fanning,* 1st ed. 1880, 2d ed. 1885-