Doubters, however, appeared on the scene—the scientist and the bacteriologist were not satisfied. Professor Dunbar of Hamburg made a visit to England, saw, examined and spoke. He said, but both your tanks are anaerobic, your contact beds stand full of sewage, oxygen is excluded during the very period when you claim nitrification, which depends on oxgyen, takes place. There is something wrong. Dibden and others would not argue, they pointed to Sutton in Surrey, and other plants and simply said, look at the results; there is an argument you can't get over. Dunbar went back to Hamburg and started experiments on an extensive scale in his own slow methodical German manner. The result of those experiments is the most valuable ever produced in connection with sewage disposal. Nearly all that was mystery is made clear. Nitrification does take place in the contact bed, but not during the period of contact. During this thought to be valuable period, practically nothing happens; the bacteria, as it were, waited in patience, waited till the liquid sewage was withdrawn and the entrance of oxygen and their feeding time commenced on the organic compounds left clinging to the filtering media from the departed liquid. The nitrates and nitrites were the result not of the last sewage dose, but of previous doses. Dunbar showed that better results could be obtained by a three-minute period of contact and a three hours rest. In fact, that the period of contact was humbug, without a single scientific point in its favor. Hence, the percolating or continuous filter and the period of contact abolished and remaining of historical interest only.

The difficulty of equal distribution has, as above explained, been overcome, the result is, no time is wasted, nitrification continuously goes on, free oxygen is ever present, and the equilibrium between retention and oxidation maintained granted that the proportions between the sewage treated and area of filter bed is correct.

The whole process of the decomposition of sewage cannot yet be said to be cleared up. Sufficient, however, has been demonstrated to prove that it is not merely the simple bacterial action as at first understood. The attacking and digesting of organic compounds by ravenous bacteria was a simple and easy explanation appealing to anyone who had ever seen the wild animals fed in a menagerie. It takes a certain length of time before a biological filter arrives at maturity; it was thought at one time that this maturity depended upon the necessary supply of nitrifying organisms being developed. Nothing of the kind! Maturity depends upon the ability of the filter to extract, absorb, and retain the organic matter both in suspension and in solution from the sewage. The power of absorption and retention depends not on the presence of micro-organisms, but on the gradual formation of a gelatinous film of a spongy character which covers the superficies of the filtering material. The film under the microscope presents a coral like appearance and has an immense power of suction and absorption. An inch in area presents about one million square inches of suction surface. The organic compounds in the sewage are absorbed by this sponge film, which is charged with micro-organisms. The presence of oxygen is necessary for its growth. In this sponge film the organic compounds are broken up and oxidized, but how much of this action is due to the mere chemical action of oxidation, and how much is due to the influence of the bacteria directly, is as yet unknown. Probably a combination of both chemical and biological action is necessary, as the sterilization of a filter by a strong antiseptic causes nitrification to cease for a time.

An interesting and practical feature in connection with contact versus percolating beds is that three times the amount of sewage can be even more efficiently treated on a given area of filtering media by the adoption of the percolating system in preference to the contact. The British Royal Commission make this point clear.

Before closing this paper it will be well to say a few words on the question of main sewerage. On the system of sewerage adopted, to a large extent depends the success of any system of sewage disposal. The main sewerage should wherever possible be on the "separate" system; that is, it is advisable that only domestic sewage, together with roof water and cellar drainage, be collected for treatment. Storm water from the surface of streets and roads must be separately dealt with, and may be allowed to discharge direct into the river or stream, as at such times the streams or rivers will be in flood and can easily take care of this large volume of only slightly polluted water. The separate system is necessary to successful sewage treatment, as it allows of a fairly exact estimate being made of the amount of sewage requiring treatment. If surface water be admitted into the sewage sewers, it means either works built to an extent enormously greater than is ordinarily required, or else with works suitable for the sewage only; it means a hopeless mess and complete unsetting of the biological system in times of heavy rainfall.

From a hygienic point of view the combined system of sewerage presents grave objections. In order to take the large volume of surface water during heavy rain storms and prevent backing and flooding of cellars, large diameter sewers must be built. The velocity of flow necessary for the removal of solids are only maintained in such sewers when running half-full or over; consequently, in dry weather, when only domestic sewage is flowing, the velocities are reduced to such an extent that they form simply long lengths of cesspools in which the solids are retained in hot, dry weather, giving off the noxious smells so common at the manholes on such systems.

The separate systems call for only small diameter pipes in which high velocities are maintained, which ensure constant, complete removal of solids, and consequently little or no sewer gases.

The cost of the separate system is generally considered against its adoption; it appears so much more simple and economical to make the one line of pipes serve all purposes. This saving is more apparent than real. In dealing with surface water it is not necessary to run sewers up all short lengths of streets. If the roadway is properly graded and there is a fall to either end, the road channel may be allowed for the drainage. When, however, it is a question of sewage disposal, any saving in cost in adopting the combined in preference to the separate system in the first instance, immediately vanishes, and if it is a case of pumping the sewage at the disposal work, then the saving in the case of the separate system at once makes itself evident.

Some are content, however, to provide what are called storm overflows, so that in time of heavy rain, when the river is in flood, the excess volume of water may be allowed to proceed direct into the stream without treatment. These storm overflows would be all right as such if they discharged only storm or surface water; but the opposite is the case. With the combined system, especially with flat or almost level grades, the large sewers, as we have seen, become stored with putrefying filth; practically, in dry weather, only the liquid dribbles through and finds its way to the treatment plant. As dry weather continues, this storage of filth goes on increasing until the long-looked-for storm comes along, fills the sewers, the storm overflows come into action, and the whole of the collected putrefying mass of filth which the works were built to purify is swept clean into the stream by way of these so-called storm overflows. Sewerage systems constructed on the above lines are the cause of the common saying: "We never had smells or illness until we had drains."

In order to show how compact the biological system of sewage disposal is and how little area it takes up, the following figures are given, comparing the amount of land necessary for various populations, capable of treating three times the dry weather flow, for broad irrigation, intermittent land filtration, and biological treatment on the percolating continuous system:—

Broad irrigation requires about one acre per 1,000 gallons of sewage per day.

Intermittent land filtration requires about one acre per 5,000 to 20,000 gallons of sewage per day, depending on the porosity of the land.