from 50 to 90% reduction with mechanical filters, as against 40 to 50% with slow sand filters.

Mechanical filters reduce nitrates and nitrites from 5 to 60%, while the slow sand filter ranges from 10 to 30%. Before discussing how these changes may be brought about by filtration, it is interesting to note that mechanical filters are much more uniform in their results than slow sand filters in the reduction of albuminoid ammonia. In three months' observation of tests made every third day, while the raw water content varied from .002 to .0067 grains per gallon, the effluent only varied in its quantity from .002 to .00265 in one series of tests. Another series during the same period, showed the variation from .003 to .0039, with the raw water containing from .0046 to .0067 grains per gallon. At the same time tests were made with slow sand filters treating the same water, in which albuminoid ammonia was present in quantities of .0063 to .0064 grains per gallon, the effluent varied from .0035 to .0059 grains per gallon. The mechanical filters, therefore, while treating water with considerable variation in quantity of albuminoid ammonia, contained practically the same amount in the effluent. In the slow sand tests the results were just the reverse, and laboratory practice further accentuates the difference.

In mechanical filters, sulphates increase from one-half to one grain per gallon, due to the addition of alum which dissociates sulphuric acid in hydration.

The presence of chlorides, unless they can be accounted for by proximity to the sea, or natural salt deposits, gives an indication of sewage pollution of the water supply. Before the advent of bacteriology, nitrates were used to determine the standard of purity, but their presence is no longer considered except to call for confirmation of sewage pollution by bacterial tests. Water high in nitrites, however, should be condemned, until exhaustive tests have been made and their source accounted for. More free ammonia than albuminoid ammonia is a sure indication of the presence of polluting matters, as in normal waters the albuminoid at least equals free ammonia. If such oxygen is consumed in testing, the probability is that pollution has occurred unless with waters high in color, where the original oxygen has been depleted in oxidizing the vegetation.

Bacterial reduction in all filters of the types mentioned, operated on the same water with the same care, and with suitable rates of filtration, with suitable water for all types, should be much the same, ranging from 85 to 100%, according to the count of bacteria in the untreated water.

The Filter Film.—In performing these changes consideration must be given to the nature of the film on the sand, and its action, so that we may be able to judge what is most likely to give constant results when dealing with any particular type of water. The film on the slow sand filter is composed of fine particles of clay and mud, of green and blue algae, fungus, bacteria, etc., which very soon propagate under favorable conditions when the water contains the original propagators. The bacterial bodies present mass themselves in zoogloea, or into colonies, and putrefactive changes in many of the diatoms produce slimy brownish masses of matter. These form a net-work over the surface of the sand, which is bound together by the active diatoms, and the whole mass coheres and feeds on other organisms, or the same placed thereon in the act of filtering. At the same time there is constant destruction going on in the film, between opposing plants, which is the primary cause of the expert attention required in the care of slow sand filters, so that the film may be guarded against rupture. Algae has quite a purifying action in the removal of bacteria, without the assistance of other diatoms, and performs useful functions in the purification of stored waters.

The whole of this mass is of a gelatinous, viscid, and sticky nature, eminently suitable for adhesion of particles coming in contact with it. Each particle of sand on the upper layers of the filter becomes wrapped in a coating of the sticky substance, and a drop of water flowing around that particle will leave any minute organisms sticking to the coating on the sand, to be sucked in and retained, if not disturbed by vibration or variations of flow in the passage of the water.

The vegetation in this film is suited to the action of nitrifying bacteria, which transform the ammonia content of the raw water into nitrates and nitrites, reducing the ammonia and increasing the nitrogen. Where a reduction of one is shown, without an increase of the other, the ammonia content has been very small, in other cases there may be sufficient ammonia present in organic matters in the water for the nitrogen to show an increase not wholly due to transformation of ammonia products into nitrogenous from the water.

Albuminoid ammonia, on the other hand, forms food for many forms of bacteria, which transform it into various fatty compounds, gases, and water. Decomposition again sets in, and nitrates, ammonia, carbonic acid and water are the final products. Thus we can readily see that the feeding stuffs necessary to the life of bacteria on the sand bed, are drawn from the water, with the consequent reduction of these food stuffs after the water is filtered.

In the film formed in mechanical filters the work performed appears to be mostly of an absorptive nature, the deposit being more like a membrane full of minute cells, which are closed, and present a very large surface when wrapping round the particles of sand on the upper layers of the filter. These minute cells of the gel are continuously opening and closing, giving up the necessary amount of water each time to equalize the vapor pressure with the surrounding fluid. It has been found that by removing the water from colloidal substances, various chemical compounds holding varying amounts of water are not formed in cycles, but that the water content changes continuously. Thus the coagulation of a hydrate makes a kind of tissue, neither solid or liquid, which encloses liquid. With this construction it may readily be understood that the enclosed water in the cells may, in being replaced by other water containing a minute organism, leave the organism in the sticky cell, when it opens to allow of the absorption of a fresh quantity of liquid.

Heat is destructive of the adsorptive properties of the gel membrane, probably by contracting or stretching the formation until the cells collapse into a flat plane. The great surface tension of the culloid and the pulsation movement of the innumerable cells, in the opening and closing, explain the suction-like action of the firm in drawing in gelatinous or minute substances, while its viscosity and stickiness aid in the retention of these foreign matters.

Every weathering process in nature is productive of some form of gel in regard to its minerals, stalactitic, botryoidal, or glassy in form, with fibrous fractures, sometimes being found even in a gelatinous state. The filtering action of nature in well waters and successful infiltrations is probably due to the action of these gels. Their absence in some vicinities certainly accounts for the