XXX.—*On Organic Matter in Water.*

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IN common with most chemists, I have for many years directed my attention to this subject, and in common with many I have long since come to the conclusion that the mere *quantity* of organic matter, nitrogenized or not, forms a very poor basis on which to found an opinion as to the wholesome character of

any sample of water. Believing, as I do, that the deleterious nature of organic matter is dependent on its containing living germs, which grow and set up a fermentative action within the body, I feel convinced that if only a few of such germs be swallowed, they may increase, under proper conditions, to a number to be injurious, and that therefore their original number is a matter of comparatively small importance. My attention has therefore been directed principally to discovering the presence of such germs, and determining their characteristic properties and appearance. I was first led to a means of doing this by being called on to assist a large manufacturer of lemonade, who some years ago almost suddenly found it impossible to make lemonade that would keep. After a day or two it became turbid, and its odour anything but agreeable. On examining the liquid under the microscope, I found it full of small spherical cells, with, in most cases, a very bright nucleus, and after a few days the odour of butyric acid was unmistakable. After examining all the materials employed, I found that the water was in fault. On putting a few grains of the purest crystalline sugar I could procure into some of the water, it became turbid in a few hours, and the same cells were distinctly to be seen with an $\frac{1}{8}$ inch object glass; but the butyric odour did not come on for some days. This water was procured from a deepish well; it was hard, and contained a considerable amount of nitrates, but not any unusual quantity of ammonia or unoxidized organic matter. On inquiry, I found some digging had been going on near the well, and it appeared that some drainage must have got in, though at the moment so small in amount as to be hardly appreciable. When water from the waterworks was substituted, every thing got right again. This led me to try all the samples of water I could procure, in the same manner; and in every case where diarrhoea or other mischief could with any kind of certainty be traced to the use of a certain water, when that water was treated with sugar, these same cells made their appearance, usually within 24 hours, if the temperature were kept up to between 60° and 70° , and plenty of light admitted to the bottle in which the sample was contained. Pressure of other business prevented my making all the experiments I wished on this subject until within the last year, when I have been trying what substances contain these particular germs, which are so

peculiar as to be quite unmistakable when the observer is once familiar with them. By permitting the action of these germs on sugar to go on, they present uniformly the following appearances. The cells gradually group together in bunches something like grapes, quite differently from the ordinary yeast globules; they next spread out into strings, with a wall surrounding and connecting the cells; the original cell-walls then seem to break, and leave apparently tubular sort of threads branched together. The strong resemblance of these to, if not identity with, the sewage fungus, coupled with the almost universal properties of water which produced them, led me to look to sewage as their source, and I found that the smallest quantity of sewage mixed with a water which might be treated with sugar, and remain clear and sweet for weeks, at once produced these germs, or rather set them growing. Water was procured from various sewers, and after standing a few days to settle, six drops of clear water were mixed with 10,000 grs. of West Middlesex and New River water. To 6 ozs. of this mixture 10 grs. of pure sugar were added. a like quantity being mixed with 6 ozs. of the water without the sewage. All these samples were placed in stoppered bottles in a window, where plenty of light could reach them. The water and sugar remained clear and sweet. The water with this trace of sewage did the same. The water, sewage, and sugar became turbid, in times varying from 24 to 60 hours, and exhibited the cells and strings before spoken of, and ultimately the odour of butyric acid was always perceptible. One drop of fresh urine in 10,000 grs. of water, a mixture which may be kept for weeks without showing any sign of turbidity, produced in 24 hours abundance of cells, and in 48 hours branched strings. No other substances which I have tried produce the same result. Urea, albumen, nitrates, milk, and various other things have been tried, and though some have produced growths of some sort, none have resembled these peculiar and unmistakable cells and strings. A curious circumstance took place during the last outbreak of cholera in 1866. On some few days the water of one of the water companies, which is ordinarily perfectly without action on sugar, produced, to a slight extent, those same growths, on being mixed with that body. The appearance of the butyric odour appears to be a question of quantity or time. If a water contain a large number of those cells, it may make its appearance in 24 hours ;

sometimes not for a much longer time; but, sooner or later, I believe it is always an accompaniment of these growths. Filtering the water through the finest Swedish paper does not remove the germs, as on the addition of sugar they grow as fast as ever. Boiling for half an hour in no way destroys their vitality. Filtration through a good bed of animal charcoal is, as far as I can find at present, effectual in removing them, and if the charcoal be well aired from time to time, it retains its power for several months; but if the water be passed continually through it without this precaution, it soon loses it, and the filtered water is as bad as the unfiltered. I am now engaged in a series of experiments to ascertain what substances, if any, retard or prevent the growth of these germs; but at present I feel certain only of this fact—that the softer the water, the more quickly they grow. In hard water their first appearance is also not a mere turbidity, but they seem to form in small clots, which on examination are found to consist of the cells mixed with crystals of carbonate of lime. The addition of nitrates or ammoniacal salts to the water, does not seem to accelerate the growth of the cells. With the view of ascertaining how far the presence of the amount of sewage which could be traced by the formation of these growths would be indicated by other means, samples of the water experimented on were submitted, before and after the addition of the sewage, to examination, by the method of Messrs. Wanklyn and Chapman, with the following results:—

New River water.

Ammonia	0·0022 grs. in gallon.
Organic ditto	0·0047 grs. „

New River water with six drops of sewer water in 10,000 grs.

Ammonia	0·0027 grs. in gallon.
Organic ditto	0·0061 grs. „

Another sample gave—

Water alone.

Ammonia	0·000 grs. in gallon.
Organic ditto	0·0031 grs. „

Water with same amount of sewage.

Ammonia	0·0056 grs. in gallon.
Organic ditto	0·0050 grs. „

Although this shows an increase, yet the amount was in neither case such as to make one suspect mischief from the water. I am by no means prepared to say that these germs are the only unwholesome kind of organic matter that exists in water, or that water containing small numbers of them might not sometimes be taken with impunity; but I should always look with great suspicion on any water in which they existed, even in the smallest number, as they increase and multiply with great rapidity; and the fact that in multitudes of cases which have come under my notice within the last few years, a great increase of health and comfort has resulted from giving up the use of water in which they could be found, even where its use had not produced positive disease, confirms me in this opinion. Whether these cells are the true butyric ferment I cannot at present say for certain, but I am strongly inclined to that opinion, and I feel quite convinced that when they occur in water they are distinct evidence of sewage contamination.