Editorial.

LONDON WATER SUPPLY.

In the Twenty-fifth Annual Report on the chemical and bacteriological examination of the London waters, Sir Alexander Houston gives a summary of his research work carried out during the past twenty-five years.

Many of the investigations cannot fail to be of interest to our readers, especially the work on chlorination. Sir Alexander writes: "Chlorination has come to stay, it was looked upon with great disfavour in 1905, but the Great War taught us many lessons and counsels of perfection have been largely displaced by doctrines of expediency. The great majority of water supplies in Canada and the United States are now chlorinated, and since 1916 the Metropolitan Water Board have greatly extended and are extending their operations in this direction—even at the present time most of the London water is chlorinated."

The change of front from hostility to tolerance and from tolerance to appreciation is remarkable. The publicity which chlorination attained during the war taught the people that the process was a perfectly harmless way of killing the germs of water-borne disease.

The story of chlorination as it developed in the Army was told in an article "On the Purification of Water Supplies on Field Service: a Retrospect," published in this Journal in September, 1925. In pre-war days the objection to chlorination was the production of taste troubles, and in the article mentioned it was pointed out that the greatest trouble was often experienced with well waters, highly polluted bacteriologically but containing little matter in suspension. It was remarkable that even after the test-box had been devised and the amount of chlorine required could be determined with some exactitude, well waters treated with a *minimum* dose might acquire the most nauseating taste.

Houston says in his report: "It seems incredible that the presence in water of one thousand-millionth part of certain substances which in themselves have no taste, except in vastly greater concentrations, should on the exhibition of a tasteless dose of chlorine render the mixture almost undrinkable. Yet it is abundantly true, and it has required an enormous amount of research to understand and combat these difficulties."

In peace time a water consumer has a right to expect that the water supplied shall be free from germs of water-borne disease and tasteless. Fortunately this result can be obtained quite easily by super-chlorination, followed by the removal of excess chlorine by means of a solution of sulphurous acid gas or a sulphite; this was the process adopted in the large plants supplied to the Army water companies during the war.

De-chlorination could not, however, be applied to the water carts without complicating the process, but as the official doses recommended really amounted to a super-chlorination, if any taste was found after treatment it was usually that of pure chlorine and not the nauseating taste produced by phenol bodies, which the super-dose of chlorine had rendered inoperative.

By means of the test-box it was possible to work out the *minimum* dose of chlorine required for well waters, usually in the neighbourhood of 0·25 part per million, but unfortunately it was just this treatment which sometimes produced the iodoform taste.

Permanganate was employed by Houston as a taste preventer as well as a taste remover, and it may be added before, with, or after the chlorine treatment; the brownish precipitate produced is a disadvantage. Permanganate may also be of great value when the taste is due to algal growths; in doses of 0·25 to 0·5 part per million it completely removed the geranium-like taste due to the growth of Tabellaria. When algal growths are decomposing permanganate is useless, and the only remedy appears to be activated carbon.

In 1910, Rideal suggested the use of ammonia and chlorine for sterilization and the prevention of taste troubles. Race, Harold and Adams have published papers on this method which Houston considers to hold the field at the present time. The treatment can be applied in two ways. In one method the ammonia and chlorine are brought together in a minor volume of water and produce a monochloramine or dichloramine compound. The product is added to the water in bulk. The proportion of ammonia to chlorine recommended is usually 1 to 4 and 1 to 8. In the second method the ammonia is added *first* to the whole body of water to be treated, and then the chlorine. Both methods are usually most successful as regards sterilization and the prevention of taste troubles, but according to Houston there is a *lag* in the full sterilization effects which in certain circumstances is an advantage, in others the reverse.

This lag may be of importance when the water has to be used immediately after treatment. In cases where the consumers receive a freshly chlorinated water, Houston "advocates the adoption of a procedure contrary to the usual sanitary principles, namely, the drinking of cistern water instead of water direct from the rising main."

The procedure followed at the Walton Works may be taken as representing the most modern method of treating one of the London supplies. *Raw* Thames water is first stored in the Walton reservoirs, then filtered, without a coagulant, though primary filters at an average rate of 130·7 gallons per square foot per hour. The next process is filtration through secondary sand filters at an average rate of 5·63 gallons per square foot per hour; this is a higher rate than is customary for slow sand filters. Finally, the water is treated first with ammonia and then with chlorine. The *raw* Thames water contained *B. coli* in 1 c.c. of 89·1 per cent of the samples examined. The chlorinated water from the general filter well contained no *B. coli* in 100 c.c. in 95·5 per cent of the samples submitted for examination. It was noted that the wash water required for the primary filters was only 0·661 per cent and for the secondary filters 0·065 per cent. In the secondary filters, on the average 320·7 million gallons were filtered per acre cleaned. A remarkable result.

Houston found that storage alone reduced the excremental microbes 96·7 per cent at Walton Works. Storage may, however, lead to the undue development of algal and other growths. Deep reservoirs, with sides which do not slope too much, clean bottoms and good circulation keep the excessive growth of algæ in check. Copper was used by the Metropolitan Water Board in 1907 to combat a growth of oscillaria, and has been employed on numerous occasions since, both as a preventive and curative measure. The results have not always been good, and Houston does not wholly approve of the treatment if it can be avoided, because sometimes the destruction of one kind of growth seems to pave the way for the growth of others of a much more objectionable kind. Further, there is the chance that the algal growths may become inured to copper, calling for progressively increasing doses of the chemical. Chlorine has been tried, but it is not a good algicidal agent. The investigations carried out at Barn Elms showed that primary filters worked at a very high rate could remove most of the algal growths from a stored water, and this led the Board to adopt the principle of a double filtration process and to construct the necessary works at Barn Elms, Walton and Kempton. The result has been a great saving in capital and working costs.

In 1912 Houston introduced the excess lime method for softening, purifying and sterilizing water. He points out that the ordinary lime-softening process is so arranged as to prevent any true bactericidal action taking place, by accurately treating the *whole* of the water with less than the amount of lime required to combine with the bicarbonates, so as to form the insoluble and bacteriologically inert carbonate of lime. In the excess-lime method the water is purposely overdosed with lime to bring about a bactericidal effect. The bactericidal dose is 1 to 2 parts of CaO per 100,000 parts of water. The excess lime may be removed in a variety of ways, but carbonization by CO_2 gas is perhaps the best method. The results obtained were very successful, and the reason why the process has not been adopted for the purification of London water is the cost of the treatment.

The excess lime method has passed the laboratory stage. The Southend Water Works Company has opened a plant, which cost over £1,000,000, for the treatment of raw water taken from the Rivers Chalmer, Ter and Blackwater by the excess-lime process. The water is extremely hard and contaminated. The plant is working well and is designed to supply 7,000,000 gallons of purified and softened water a day. *B. coli* have not been found in 100 cubic centimetres of the treated water, and the hardness averages 10 parts per 100,000.

Houston states that he used to think that the discharges of birds, fish and the lower animals, although sentimentally objectionable, were relatively harmless in a disease-producing sense. He has modified this view to some extent since Adams discovered *B. typhosus* in the droppings of gulls at Belfast, though this discovery has not yet been confirmed in the case of London gulls. The droppings of gulls contain at least a million *B. coli* per gramme, and it is impossible to distinguish these from those derived from human beings. Gulls are thus a great source of embarrassment to the bacteriologist in drawing conclusions as regards the safety of a water. Houston thought a study of bacteriophages might help, but the investigations proved disappointing, as by their use it was found impossible to distinguish between the coli of human beings and those derived from birds and the lower animals.

Sterilization of water by the action of metals has attracted a good deal of attention lately. Recently the sterilizing action of silver has been studied by Degwitz, Krause, and others, and they have obtained a very spongy form of the metal which Krause calls "katadyn."

In 1929 Lakhowsky immersed silver spirals in the water to be treated, and *B. coli* and pathogenic organisms vanished after several hours. If the spiral was removed the water still remained germicidal, but lost this property on filtration through a Chamberland filter. Lakhowsky considers that the results are due to a physical action, viz., that the spirals alter the frequency of the cellular vibrations which are supposed to exist in the interior of cells.

Sand silvered by the process of Kayser has been tested by Dienert, who found that Seine water containing 46,000 microbes per cubic centimetre was rendered sterile by half-an-hour's contact. The disappearance of *B. coli* is still more rapid; they could not be found after several minutes. Water which has passed through silvered sand contains less than 0·003 milligram silver per litre and yet retains a certain bactericidal power. When mixed with an equal quantity of ordinary water containing 27,000 *B. coli* per cubic centimetre, the bactericidal action reduced the *B. coli* to 500 in one hour, to 20 in three hours, and to 0 in forty-eight hours. The work of Drs. Beale and Suckling on the action of catadyn sand leaves no doubt as to the efficacy of the process. The water to be treated must be quite clear and not in such a condition as to coat over, and so render inoperative, the particles of sand.

Houston has made a few experiments with catadyn sand and obtained good results. Unfortunately the sand is expensive, which militates against its use on the large scale, but he thinks that for household purposes the catadyn treatment of water would seem to have a considerable future.

In last year's report Houston recounted his experiments to discover pathogenic organs in *raw* river water; this year his experiments have dealt with sewage. Average samples of crude sewage were collected at the Barking outfall hourly during twenty-four hours and then mixed proportionately to the flow. Wilson and Blair's glucose bismuth sulphite medium was used; Houston thinks it is much the best medium for the purpose. The sewage was divided into two portions, A and B. A was not infected; B was purposely infected with definite numbers of typhoid bacilli. In 34 experiments with A the typhoid bacillus was recovered only on four occasions, though as many as 200 colonies were examined in most of the experiments, and 5,624 colonies were examined during the investigation. In 34 experiments with B, the infected sewage, the typhoid bacillus was recovered on every occasion, although the number of bacilli added in one experiment was only 11 per 0·1 cubic centimetre. The results seem to indicate that the bacteriological standards for potable waters provide a larger margin of safety than would otherwise have been supposed.

Search was then made for paratyphoid B in separate samples of sewage, because Allan, and later Gibson and Begbie, found paratyphoid organisms in Edinburgh sewage. Houston never recovered the paratyphoid B from the non-infected sewage, but from the infected sewage he recovered it in each experiment, though the number of bacilli added on one occasion was only 50 per 0·1 cubic centimetre.

Since writing the notes on these experiments, Houston has had the opportunity of examining the sewage effluent (land treatment) from a town during a paratyphoid B outbreak. The picture here presented was totally and almost unbelievedly different, and enabled him to visualize how easily an epidemic might arise from the contamination of a drinking-water supply with even traces of such a liquid. The effluent was found to contain initially seventy-three paratyphoid bacilli per cubic centimetre, and the infection persisted for months.

The value of the streptococcus test for waters has been a debatable subject for many years. In 1898-99, and in subsequent years, Houston reported to the Local Government Board on the significance of streptococci. He wrote that "Some fæcal streptococci are of feeble vitality, and that the presence of such streptococci in the water, if they could be differentiated from their more robust companions, would seem to indicate pollution of recent and therefore specially dangerous sort."

A good deal of work was done on fæcal streptococci, but without any very definite solution of the problem of *recent* contamination of a potable water by means of the streptococcal test.

The *B. coli* test came to be regarded as the easiest and most delicate method of judging excremental contamination of a water supply. If streptococci fermenting lactose were discovered during the ordinary examination, their presence was considered merely as confirmatory evidence of fæcal contamination.

A lactose bile-salt medium favours the growth of *B. coli*, and to a much less extent that of streptococci, at the expense of most other organisms. As a result coli colonies are apt to crowd out those of streptococci on Conradi-Drigalski plates. But Houston has found that if the growth in the liquid lactose bile-salt medium is spread on a plate and dried in a *moist* chamber, the streptococci are more resistant than the coli, which are killed. He spreads a few drops of the liquid medium in a thin film on the bottom of Petri dishes. The dishes with the covers raised are put in a *dry* incubator at 37° C. for fifteen minutes to dry the liquid on to the glass; they are then transferred to a *moist* incubator (eighty-five per cent humidity) for about three-quarters of an hour. Next, thirty to forty centimetres of melted agar are poured into the dishes, which are incubated at 37° C. Almost a pure growth of streptococcus colonies will be found on the under surface of the agar next the glass.

When examining water in baths and bathing pools, as it is necessary to determine the presence of salivary as well as fæcal streptococci ordinary agar must be used, as the Conradi-Drigalski medium inhibits the growth of salivary streptococci. If streptococci are found with long chains which ferment lactose but not salicin, they are probably of salivary origin. Salivary streptococci, unlike fæcal streptococci, form relatively long chains and are easily detected even when the amount of saliva added to a *raw* water (Thames water) is as small as one part in 1,000,000 parts.

The streptococcus test is undoubtedly useful in examining the condition of water in baths, and is also valuable as a corroborative test of fæcal contamination, but it cannot tell us whether a water has been recently contaminated, nor can it at present help us to differentiate between human and animal pollution.