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Proceedings of the Madras Government, Public Department,
19th August 1869.

No. 156. Read the following despatch from the Right Honourable the Secretary of State for India, to His Excellency the Right Honourable the Governor in Council, Fort Saint George ; dated India Office, London, 24th June 1869, No. 12, (Sanitary.)

I forward, herewith, for the information of your Excellency in Council, and for the adoption of such measures as may be deemed expedient, copy of a Memorandum by the War Office Sanitary Commission relative to three reports on analysis of potable waters of Cantonments, Bengal, by Dr. Macnamara.

2. I also forward copy of a paper of remarks placed at the disposal of the Commission by Dr. Angus Smith, with a view to its communication to the officers engaged in these analyses in India.

3. I desire that your Excellency in Council will issue the necessary instructions for obtaining reports on potable waters in the Presidency of Madras, in accordance with the recommendations of the Army Sanitary Commission.

Memorandum by the Army Sanitary Commission on Analyses of Indian Waters.

The Royal Commission on the Sanitary State of the Indian Army recommended that a careful analysis should be made of Indian waters,

1. Reports on Water Analysis in Bengal, 1867.
2. Report on Analysis of potable waters of Cantonments in Bengal Presidency, 1868, by F. N. Macnamara, M.D.
3. Third Report on Analysis of potable waters in Bengal Cantonments, by F. N. Macnamara, M.D.

and these reports on Bengal waters are the first instalment of the results of this inquiry.

The examinations have been generally properly conducted, and have afforded, for the first time, a true insight into the condition of water supply in India, and into the relation of source and quality of water to the health both of troops and of civil population.

It may give some idea of the magnitude and importance of the work to state that, within little more than a year, the principal water sources of thirty-eight cities, towns, and stations, extending from Calcutta north-westward as far as Peshawur, have been examined, some of them at different seasons, and that nearly 400 water sources have been analyzed, and the results tabulated for use.

Of the water samples analyzed—

65	were	taken	from	tanks.
4	„	„	canals.	
26	„	„	rivers.	
9	„	„	lakes.	
2	„	„	springs.	

The remainder were from wells, with few exceptions, of shallow depth, most of them dug in cities, or within the boundaries of cantonments.

The general plan of the analyses may be stated as follows :—

Physical properties of filtered water.

Reaction, alkaline or neutral.

Hardness, permanent or removable.

Proportion of oxygen per 1000 for destroying readily oxydizable organic matter, (the most injurious to health).

Amount of ammonia, phosphoric, nitrous, and nitric acids.

Total solids, fixed and volatile, with their approximate nature.

Soluble salts, and their nature.

The results of each inquiry are given under these heads, and they possess a high scientific interest apart from their bearing on the public health. We shall, however, confine our remarks solely to questions of health, and these, as we shall presently see, are of great importance.

The plan of analysis is based on Dr. Angus Smith's "estimation of organic matter in water, with reference especially to sanitary purposes," which was printed and circulated extensively among Army Medical and other Officers in India, at the request of the Army Sanitary Com-

mission. In this paper, Dr. Smith gives simple and efficient rules whereby the nature and probable sources of noxious organic matter in water might be ascertained, and he lays down certain general principles, by which the effect of impurities on health may be approximately estimated.

This can now be done for nearly every one of the waters submitted to analysis in India. But, before proceeding to state what are the results arrived at, it will be necessary to enumerate, briefly, the general principles referred to.

Besides ascertaining the precise nature and amount of saline matters in water, and their probable effect on health, the plan of analysis enables us to ascertain the proportion in any given water of rapidly oxydizable organic matter, together with its origin, in some cases with certainty, in others with probability; whether it is of animal or vegetable origin; whether it is in a decomposing condition, and consequently more or less of a poisonous character at the time it is drawn for use; whether the organic matter enters into this dangerous state after the water is kept a short time; and, lastly, whether the organic matter is of recent origin or of old date.

The class of organic matter most important in a sanitary aspect is that which proceeds from decomposing animal debris, and the test which enables the chemist to distinguish this with an almost certainty is the co-existence of organic matter in water with certain salts and saline bodies. These are, ammonia, nitrates, nitrites, and common salt. The last of these is, perhaps, the most important, for if its presence cannot be traced to sea-water, spray, or salt deposits in the soil, it can have but one of two other origins; it must proceed from certain processes of manufacture in which salt is employed, or it must have passed through the bodies of men and animals: in other words, it must proceed from sewage. As Dr. Angus Smith gave every needful caution* for avoiding error in estimating the source of common salt, when analyses are given without assigning the salt to any natural source, we must conclude that the common salt in these waters, in all probability, proceeds from old or recent sewage impregnation, with which the soil yield water to the well has become charged.

The ammonia has, for the most part, a similar origin.

Nitrites mark the existence of organic matter undergoing decomposing changes. Nitrates indicate the change completed.*

As an illustration of the test for organic matter, Dr. Smith gives the result from four natural waters examined by him.

First.—The water supplied to Manchester contains, in every 1000 grains, as much readily decomposable matter as requires 25-millionths of a grain of oxygen to decompose it.

His sample No. 2 required 500-millionth parts of a grain for the same purpose.

Sample No. 3 required 2200-millionths of a grain, and No. 4 required 5500-millionths of a grain to destroy, not all the organic matter it contained, but only the readily oxydizable matter which, as already stated, is the most dangerous to health.

He shows that, as regards organic matter readily decomposable, the waters contain the following relative proportions:—

Manchester Water, No. 1...	...	...	...	1
Sample No. 2	...	...	...	20
„ No. 3	...	...	...	88
„ No. 4	...	...	...	220

But without the other tests mentioned it would be impossible to arrive at the origin of these amounts of organic matter. Here the amount of chlorides becomes of importance. After stating that in England it is almost universally the case that the presence of much chlorine in water indicates drainage from animal matter, Dr. Angus Smith states that one grain of common salt per gallon is too much, and is in many places to be suspected of being caused by impure drainage,

* In estimating the probable origin of saline matters of this class in India, it must, however, be borne in mind that over large parts of the North-West Provinces the natural soil is impregnated with salts, including an appreciable proportion of common salt, as, for instance, in districts where “Reh” exists, and that there are tracts where the nitre of commerce is found, and manufactured from the soil. A probable origin of part, at least, of these saline matters in certain districts of country is the former occupation, and sewage pollution of the ground, by populations which have long since removed from it.

and, further, that if chlorides and nitrates are found in water in which easily decomposable organic matter is also indicated by the usual tests, “the presence of animal matter, or injurious gases, or nitrates may be assumed.

“Nitrites may be considered as hurtful as organic matter until their effect is better known. Their presence is suspicious, and their company bad.”

Dr. Smith states his opinion that water which requires 50-millionth parts of a grain of oxygen to decompose the organic matter in 1000 grains of water is sufficiently free from organic matter, but the quantity beyond this which can be borne without danger is not known. It is a question of degree, to be determined by experience.

If we assume the Manchester water as a practically attained standard, the quantity of oxygen will be 25 millionth parts of a grain.

Bearing these principles in mind, let us now see what is the condition of these Indian waters, as given in the reports before us.

As a general rule, water samples taken from Indian rivers, mountain streams, mountain lakes, and similar unpolluted natural waters, do not afford those indications of sewage-impurities to which we have referred.

They all contain readily oxydizable organic matter in a greater proportion than Manchester water; but as this is accompanied neither by an excess of chloride of sodium, (common salt,) nor by ammonia, nitrites, or nitrates, the organic matter is most probably of vegetable origin and innocuous. But when waters of this class are taken near groups of population, or when they are conducted along open channels, exposed to the risk of impurities, they give sufficient evidence of deterioration to show the necessity of filtration and covered storage, and of improving the means of distribution.

The water supplied by tanks, provided the tanks are carefully kept, stands next in order of purity. Tank waters generally contain a considerable amount of rapidly decomposable organic matter, from 50-fold to 100-fold or more, the amount of organic matter in Manchester water. The amount of chlorides is generally small, and there are only traces of nitrates. The organic matter may, therefore, be considered as mainly of vegetable origin. But when natives deal with tank waters as they choose, of course the entire character of the impurities undergoes a marked change. The presence of sewage matter is then obvious enough.

The worst of all the northern Indian waters are those on which both troops and Native population depend mostly for their supply, namely, water from shallow wells.

With very few exceptions, these waters show a considerable degree of pollution by organic matter in all the stages of it recognised by chemical analysis, and of those impure well waters in which the organic matter has been so far oxydized as to form nitrates the physical qualities are good.

The proportion of readily oxydizable matter often exceeds that of the Manchester standard 40, 50, and 100-fold,* while the presence of common salt to the extent of several grains per gallon—sometimes to the extent of between 70 and 80 grains per gallon—indicates that the organic matter is most probably of animal origin. A large proportion of these well waters contain ammonia due to fresh sewage, and also nitrous acid and its accompanying phosphates, indicating the presence of sewage matters undergoing oxydization in the soil. In many cases, the greater part of the readily oxydizable organic matter has been already oxydized in the soil, and appears in the well as nitric acid compounds, often to the extent of several grains per gallon.

Depth of well, as shown by the reports, is no safeguard against impurities, if foul matter is allowed to enter at the well's mouth, or if the immediate surface yields foul water to the well. There are instances given in these reports of wells 90 and 100 feet deep yielding both ammonia, nitrous, and nitric acids, in addition to organic matters.

* With reference to these quantities, Dr. Angus Smith, in his paper afterwards referred to, makes the following remarks:—

“The permanganate (the re-agent made use of for oxydizing putrescent organic matter) does not seem to have borne so much fruit in India as I expected. I should have expected more striking results. * * *. If it does not show greater amounts of putrid matter in some of the waters it will, of course, surprise me.” Dr. Smith points out that this result is probably due to the water having stood some time before being tested.

In most cases there is no difficulty in tracing these impurities in well waters to their source in the foul neglected state of the ground round the well's mouth, to the method of drawing and of sloping the surface by which foul water is thrown directly back into the well, to the proximity of latrines, cook-houses, stables, and dwellings, to the long use and occupation of the surface in which the well is dug, and to similar causes.

It may be stated here that in a number of instances filtered waters, which had passed through the ordinary barrack and hospital filters, were found to have benefited very little by the process. In some instances, indeed, filtered water contained more organic matter derived from the filter than was contained in unfiltered water: a result which has been observed when filters, especially small filters, are used too long without cleansing or removal.

It may be remarked that water impurity may be increased by natural processes of vegetation in water impure enough for the purpose. Thus, when the organic matter is in solution it is not always perceptible, but when growth begins it is taken out of solution and seems to increase. Thames water at London, if allowed to stand in the sun, used to take an appearance of solidity, so abundant were the green weeds in it and within the whole vessel.

The reports being intended to give the chemical constitution of the waters, do not enter specially into their influence on health of troops and civil population. But, nevertheless, there are notices here and there which sufficiently indicate what the influence probably is. Take, for example, the case of Peshawur, a station which has been scourged by cholera and fever to so great an extent, and which suffered so severely from cholera in 1857.

This station is supplied partly by feeders from the river Barra, partly from wells. The artificial channels traverse every street, they are simply open ditches carried above the level of foundations of barracks and houses; there are miles of them in cantonments; they are filthy and frequently choked up with mud; secondary streams supply the regimental tanks. It is notorious that these streams are polluted in consequence of the careless and disgusting habits of the natives.

Native houses are built close to the main stream, and cattle are kept close to it. Natives wash their bodies and utensils in it. A native was seen to be taken ill with vomiting within a few feet of the bank of the main stream in the 42nd lines.

The Artillery well is only 11½ feet deep. There are old graves all round the well, and the place is a favourite resort of washermen.

Dyeing processes are carried on round the mouth of the jail well, and the dye-water is allowed to stagnate on the surface, and emits a most offensive odour.

The water is stated to be so bad that the prisoners should not be compelled to drink it. The fort water is so salt and bad that it is used only by native workmen.

These few facts, mentioned incidentally in the reports, show that, so far as concerns its water supply, Peshawur has been simply made a nest of epidemic diseases, resembling the south of London in the days of open ditches and bad water. And they indicate clearly what ought to be done. So long as these ditches are left in existence, and so long as the water supply is such as it is described to be, there is little hope for improved health among troops stationed at Peshawur. A competent Sanitary Engineer would very soon detect and remedy the evils.

Take another example, Delhi. Some time ago the Commission reported to the India Office that there was reason to believe that the sanitary state of Delhi, including the condition of its water supply, was a cause of the "Delhi sore."

Delhi is supplied with water from wells dug in the nitrous soil of the city. This nitric acid appears to be the result of a continuous impregnation of the soil, in houses and compounds, with urine and feculent matters. In proof of this, Dr. Sheppard shows that, while water taken from a well dug in the old cantonment, at a distance from houses, gave "not the minutest portion of nitric or nitrous acid or ammonia," a sample of earth taken within the city, from a locality formerly occupied by houses, yielded "an immense amount" of these sewage products.

Part of the water of Delhi is supplied from the river Jumna.

Dr. Sheppard gives the following facts in relation to the "Delhi sore," and the quality of water, but he also attributes part of the susceptibility to this disease to the impure air of the city.

Jumna water contains twice the amount of readily oxydizable matter existing in Manchester water. But it contains only eight-tenths of a grain of common salt per gallon, and affords no trace of ammonia, phosphoric, nitrous or nitric acids.

This water was used by the right wing of Her Majesty's 98th Regiment, among whom there were 15.6 per cent. attacked with "Delhi sore" during the first year's residence, and 10.7 per cent. during the second year. The decrease was 4.8 per cent.

There are two wells which supplied water to the 25th Native Infantry, namely, the Delhi gate well, and the Khyrattee gate well. The former contains 137 grains of solid matter per gallon, of which apparently only a minute quantity consists of readily oxydizable matter. But instead of this there are no less than 15 grains of nitric acid, 41.3 grains of common salt, and 33.7 grains of sulphate of soda per gallon.

The Khyrattee gate well contains more organic matter, 10 grains of nitric acid, 29 grains of common salt, and 19 grains of sulphate of soda per gallon. Its total solid constituents exceed 92 grains per gallon.

The regiments using these waters yielded 8.5 per cent. admissions from "Delhi sore" during the first year, and 23.9 per cent. during the second year of residence, showing an increase of 15.4 per cent.

The Putthur Ghatti well, used by the Royal Artillery, contains three times the amount of readily oxydizable organic matter that there is in the Manchester standard. It contains ammonia, 1½ grains of nitric acid, and above 4½ grains of common salt per gallon. It contains a considerable amount of inflammable nitrogenous organic matter.

The Royal Artillery, using this water, afforded 15.6 per cent. admissions from "Delhi sore" during the first year's residence, and 43 per cent. during the second year, showing an increase of nearly 27½ per cent.

Dr. Sheppard further calls attention to the non-development of "Delhi sore" in former years among British Officers and Native troops who lived in the purer air and used purer water of the old Delhi cantonments, and to the absence of this sore in Meerut, where the water supply is purer.

The possible influence on the skin of these highly nitrogenized waters, when used for ablution, has likewise not escaped attention.

Dyspepsias and diarrhœas have also been traced to their use.

One illustration more will suffice. Many of the wells in Oude are so bad that Assistant Surgeon Orton, who visited the cholera districts of the province in 1867, reports that in every instance, without exception, the drinking water was filthy, or, as the Natives themselves expressed it, putrid. A glass of it would produce diarrhœa at once in a person unaccustomed to partake of it. It is loaded with sulphates, chlorides, nitrates, and organic matter. Mr. Orton further states that, where cholera prevailed among troops, the water supply was similarly objectionable.

On the other hand, he mentions that at the Havalet, where the water is bad, fever, diarrhœa, and dysentery were invariably the prevailing diseases, till the use of the water was prohibited by an order of the Magistrate, and he says that since this was done scarcely a single case has come under his notice.

As a general rule, the well water supplied to sick in hospitals appears to be even more impure than the barrack supply.

It will be seen that this, as yet partial examination of Indian waters, has opened up an entirely new chapter of the disease causes in India.

Suspicion, which formerly prevailed as to the efficient operation of this cause of ill-health among troops and civil population, has become so strongly confirmed that the only question is what should be done.

First.—In the first place, it is evident that these chemical examinations should be continued all over India, and that especial attention should be devoted to waters used in localities where

cholera, dysentery, and fevers are endemic. And in estimating the source of the saline constituents in water, it might be well to analyze samples of soils and subsoils at different depths and in different localities, with a view of ascertaining whether these salts are due to the geological conditions, or to old or recent impregnation of the soil with sewage impurities.*

Secondly.—There are the practical questions of water sources and means of distillation. In regard to these points, there is nothing indicated in these reports which has not occurred elsewhere. Like evils require like remedies. In former days, London, as well as other cities and towns at home, suffered from precisely similar water impurities, arising from similar causes. London was formerly drained into cesspits, and derived its water supply partly from the impure river at London Bridge, and partly from wells among the cesspits. We have no chemical account of these waters, but we can form a very good idea of their nature by analyzing the existing wells even after the metropolis has been drained. This has been done, and not a single well is fit for drinking purposes. During epidemic seasons, many are poisonous, like the well in Oude.

London was formerly scourged with fevers and dysenteries, just as India is, and yielded an enormous death-rate.

The practical solution of the water question for India is the same as it was for London.

All old wells among groups of population in cities, villages, bazaars, and the like, which afford such waters as the wells submitted to analysis have done, should be rendered impervious to any infiltration of surface water by careful puddling or other methods. It has been stated, for instance, that an impure well at Bangalore was purified from foul surface drainage water by so simple and inexpensive an expedient as digging and removing the soil round the well's mouth to a distance of six feet from the tube, and about the same depth from the surface, and filling the space with clean sand.

After cutting off the surface drainage, the true deep subsoil water should be tested, and, if good, may be used, but if bad, then the well should be filled up and closed with as little delay as possible. Wherever these waters show readily oxydizable organic matter, requiring an amount of oxygen exceeding 0.000,050 of a grain per 1000 grains of water, together with a grain or two of common salt per gallon, or wherever there is ammonia present, or nitrites in any quantity, or organic matter, nitrates, and common salt, it may be considered certain that the water is unsafe during epidemic periods, and that its constitution cannot be depended on.

Thirdly.—The best available sources of water in India, as shown by these examinations, are rivers, streams, and lakes, and in some places impounding reservoirs might be advantageously constructed. Properly-constructed tanks, which are a species of impounding reservoir, would answer in localities where the requisite facilities existed for their construction, provided due care were exercised in protecting the water from pollution, and in sand filtering it before use.

The roof water of buildings, if filtered and stored under cover in places where it would not become impure by soakage of foul surface or subsoil drainage, would form, in many cases, an important source of supply for drinking and cooking purposes at military stations.

Wherever new wells must be depended on, they should be sunk in the cleanest ground available, and at a distance from dwellings, and from all sources of impurity. The top should be built up and covered, and care should be taken to cut or puddle off the immediate subsoil water from the well.

Fourth.—It would be very desirable to improve the means of raising, conducting, and distributing water, so far as it might be practicable to do so, at stations where the present methods of distribution are found to add to the impurity of the water supply.

In conclusion, we would beg to suggest that the whole subject of these water sources may at once be taken up in India, with the view of devising some practical method for providing troops and civil population with pure water.

ARMY SANITARY COMMISSION, WAR OFFICE,

April 12th, 1869.

* Dr. Angus Smith, with whom we have communicated regarding the results of his plan of analysis, already referred to, has placed at our disposal a paper of remarks, a copy of which we have appended, with the view of its being sent to the chemists engaged in this work.

NOTES by Dr. R. A. SMITH, with reference to the *Analytic Examination of waters in Northern India, described in Dr. Macnamara's Report.*

16th February 1869.

I send a few notes after thinking over the analyses. They add a little to what was said, and may be of use if taken in good part by the analysts.

I am inclined to increase the number of questions relating to water. The value of many methods lies in the fact that there are many varieties of waters. I have put down, therefore, one or two more divisions of organic matter. Each may be useful in its way. Glad I am to see that the work is good, but naturally one feels inclined to wish always for more.

(Signed) R. A. SMITH.

When we seek an analysis of water, we merely desire such a full description as will enable us to see at once its character, and, therefore, we require something of its natural history. With this in our minds, we may consider if the late analyses of Indian waters satisfy every demand.

On looking over the work, I consider that a good idea of the waters is obtained, and that the results will be of immense value. As it is difficult to be perfect, I may be allowed to draw attention to some questions, (rather, I ought to say, according to request I do so).

In all analyses of water I look on the organic matter as the most important point. I can imagine a very satisfactory investigation into the quality of the water where nothing but organic matter was spoken of. Instead of one or two columns, I would give many to this point.

First, the description of the water.

It seems to me not to be very full, unless it be that there is uniformly little to observe. The same fault is found in analyses made here. Having a fellow-feeling with chemists, I do not wish to see them burdened; it would, however, be well if they gave themselves a little experience in examining the organisms in the water as soon as collected, and later. A little of the deposit taken up and examined by a small microscope,* with a half-inch power, would give a valuable experience, even without the scientific names of the bodies seen.

After the water had stood, protected from air, for some days—in our climate (Great Britain) a week or so—it could be examined again. This will show if there is much vegetable or animalcular life.

So far as I know, there is no such examination published as will distinguish (by the animal life) good and bad water. Forms of all kinds are generally shown together, and the time of careful distinction has not come. It does, however, seem to me that fleshy or gelatinous forms are the most hurtful, as they also are the most disgusting. They seem to abound according as the water becomes worse, until a stage comes which destroys even them, bringing putrefactive gases and vapours.

It would be easy for the chemist to indicate these forms, and observe without much detail. I should not complain of waters at the bottom of which were deposited many of the forms of diatoms or desmidiaceæ, or in which were swimming even the larger entomostraca, if carefully removed, unless they indicated something worse, although not readily seen, whilst I should fear water in which were floating the beautiful volvox or the englewa. If there did not exist material for the formation of these creatures they could not be found, and the material for the latter is hurtful.

This mode of developing them, at a proper temperature, and then observing them, is the simplest of all modes of examining water, and can be managed by any one. It is of value even without a microscope, but of more value with one. I wish simply to reduce into a scientific form the common and approved modes of observation, as our first step. One or two microscopes might be sent as a commencement, to see if they bear fruit.

* A Stanhope lens might be used for such purpose.

There are cases in which gases are found as the results of decomposition, and in such cases by the usual modes of analysis they are entirely lost; the amount of organic matter, in weight, gives no idea whatever of the state of the water. Indeed, as a rule, the amount of organic matter in weight is of little value. Although I have often said this, and first said this, I see I am quoted with a very different meaning.

This putrid state is the only one which the permanganate was proposed for measuring. No other method does measure it, or even pretends to measure it. The permanganate does not seem to have borne so much fruit in India as I expected. I should have expected more striking results. There seem to be different modes of reading off. In one case there is sulphuretted hydrogen; even that has only slightly affected the permanganate.

Possibly greater quantities of water ought to be used. For example, it would be better, when possible, to use 100, or, still better, 1000 centimeters, and reduce afterwards to any standard amount.

In order to diminish the fractions it would be better to change the decimal place, and to say "oxygen required for one million parts of water." This would do either for grains or cubic centimeters, and avoid the conflict of measures. It is merely a change of the decimal point three figures to the right. Still its results have been valuable, although no one has gone with interest into the details of the use of the permanganate. If it does not show greater amounts of putrid matter in some of the waters it will, of course, surprise me. It certainly may happen that the gases leave the water in warm countries sooner than with us, but then they are formed more rapidly. The test, however, is delicate, and it requires some time to know its peculiarities. It has been objected to it here that it is acted on by iron and nitrites. That is surely no real objection to a chemist, who will estimate these separately.

One reason why it has done less good is seen on a remark that the water was allowed to stand twenty-four hours before using permanganate, as it took up less then.

That fact shows that the test was right, but the gas having escaped during the twenty-four hours, it could not be measured. However, a valuable piece of information was gained by this, namely, that putrefaction was not forming new gases. If it is common to use the water only after standing that time, then also Dr. Macnamara had the most practical view of the case, but not its history.

Delicate as this is, it tells us nothing of the solid matters undecomposed, and nothing of the growths that may take place when it is used cold, in the way which Forchhammer devised, and which I simply followed with details.

If we want to know the amount of matter containing nitrogen, we must use it heated, and along with soda or potash, as Mr. Wanklyn has shown. His mode of first removing the ammonia by boiling with carbonate of soda, and keeping the distilled product, testing that then for ammonia by Nessler's test, is very instructive. When this is done, it is again boiled, after adding caustic soda and permanganate; the ammonia then collected and estimated as before. It seems to me well to use this test also as an indicator of the nature of the organic matter. Some chemists will probably take to one more than to the other; I do not well see that we can dispense with any of them when the work is to be done for a great national purpose, and when we may expect the analyses to be models for the world, as they certainly may be expected to be when done by a great nation for another in many respects greater.

The advantage of Wanklyn's process being added to the others will be felt very strongly in cases where there are nitrates. Then the process by burning causes a loss both of organic matter and nitric acid. This loss is put down as organic matter frequently, and the true organic matter is never seen. Wanklyn's process will find it by showing the nitrogen. As it does not show the putrefactive power of water or its organisms, it must not be used alone, since it may give alarm when there is really no danger. On the other hand, it will not fail to give alarm when there is danger of putrefactive matter.

The cold permanganate reaches the matter which may become decomposed, the hot process at which may decompose. It is well to add new processes, they always give more knowledge. certainly would recommend a fuller examination of the organic matter. These are the most important methods of doing so.

It is, perhaps, well to give, along with the hardness as a whole, the permanent and removable, but it is not of great importance in India at present, where it is not probable that Clark's process of softening will be adopted. I should prefer to see stated the amounts of sulphate of lime and the amount of carbonate. These results are distinct, definite, and of value for future use, and have a more scientific meaning, in other words, a value of wider application, the mere softening or hardening has a relation only to empirical processes of limited use.

Volatile matter is important. It is, however, good to state if the matter is entirely organic; for example, there is much nitric acid, the organic matter is oxidized by the acid, and both go off, leaving a very white ash.

The magnesia water has been mentioned as being considered hurtful. If there is any suspicion of this, the amount of the base ought always to be given in the analysis in full; indeed, it is better to have the analyses full under any circumstances. We know, however, that no injury arises from three or four grains of carbonate of magnesia in a gallon in England. At least we fear this, as that amount is so common.

Of silica we know little, in a sanitary point of view. It is probable that no amount will be injurious. I generally find from a third to half a grain in a gallon. It is well to give it in those cases in which the analysis is carried so far as to bring it easily into the hands, but not to evaporate much for the purpose.

Of the inorganic substances, none have been so capable of indicating the quality of a water as the chlorine. The chlorides, or, we may say, "common salt," is almost universally found in bad waters, showing sewage. The attention to this substance has been successful. I always take abundant care that no inorganic sources of this salt will mislead. There ought, however, to be some waters which give little chlorine, and which are still hurtful, viz., marshy waters. It would be well to give some attention to this subject, it is new and unknown; such water has bad qualities, of a vegetable origin wholly, as I suppose.

As to the mode of retailing the analyses, a little license, of course, must be allowed, since there are various ideas, but as much uniformity as possible ought to be sought. I should prefer to see the words "permanent" and "removable hardness" replaced by a careful statement of the carbonic and other acids, with all the bases. The most complete way is the statement of the salts, but some theoretical difficulties prevent it being fully carried out. These might be got over; we could estimate the potash precisely, but that is a very troublesome operation, at least chemists generally avoid it. If any objection is made to it, it might be left out, and soda allowed to stand for the alkalies. In this country the amount of potash in waters is extremely small, and is generally omitted in analyses; it is, however, always present in the waters. In a country comparatively new to these inquiries, it would be well to inquire if there are any waters with a considerable amount of this alkali. I do not see it mentioned.

The question may be asked, "Is it well to make the examination with the greatest minuteness at once, or to leave the fuller inquiry to a future time?"

I am inclined to think that attention to organic matter ought to be given first for all specimens, whilst selected specimens are examined with all the minuteness which chemistry can give.

There is a want of peculiarities among the waters. I should have expected in India something not the same as here, but this may be groundless fancy.

Careful examination for rare bodies would be of great value. Such examinations of inorganic bodies as Frezenino makes of the bath waters of Germany, which would occupy a chemist many weeks. An analyst might have one of these continually on hand whilst going on with the less minute and more practical inquiries on other specimens.

The following headings might be given, or a selection according to circumstances:—

When the water is collected.

1. Physical properties.
2. Vegetable and animal life visible to the naked eye.
3. Vegetable and animal life seen by the microscope.

When the water has been kept a week.

- a. Physical properties.
- b. Vegetable and animal life visible to the naked eye.
- c. Vegetable and animal life seen by the microscope.
- d. Appearance.
- e. Reaction.
- f. Hardness, permanent and removable, if desired.
- g. Oxygen required by a million parts of water.
- h. Nitrogen from nitric acid, old organic matter.
- i. Nitrogen from nitrous acid, recent organic matter.
- j. Nitrogen from ammonia, recent organic matter and rain.
- k. Nitrogen by Wanklyn's process, present organic matter. (Boiling with caustic soda and permanganate).
- l. Organized organic matter by description.
- m. Probability of much animal matter.
- n. Probability of much vegetable matter.
- o. Gases from organic matter decomposing cold permanganate.

We cannot expect one analysis to go over all the ground, but I think we have in the preceding list a certain goal to which we may attain, sometimes perhaps when a water must be perfectly examined, filling up actually every space.

There may be added also as a mode of comparison—

1. The best Indian waters take of oxygen.
2. The best Indian waters give of ammonia.

The ammonia got by boiling with the carbonate of soda consists of that which is inorganic, the rest has been formed by the boiling process from organic substances containing nitrogen. Every one of ammonia is equal to ten of albumen.

I think it would be better to introduce a decimal amount of water instead of the partially decimal gallon. The French introduce 1000. This gives rise to too many fractions. I have been using a million for air for some time, and whenever it is decided to abandon the gallon I think it will be better to take a *million parts*. Continental nations will then find it more convenient to read our analyses than their own.

It was my intention to send a specimen of the full analysis. At present I am not ready, and am considering modes of shortening the work considerably, whilst at the same time the results are increased.

Frankland's process for nitrogen is unnecessary when Wanklyn's is used. I could not recommend the first for India, as it is complicated. I know the second to be valuable; time will show the extent of its accuracy.

I do not consider it necessary to divide the organic matter in all cases into such a great number of portions, but in all cases one or more of these portions are wanted, and there may be cases which are worth such a full examination that all will be taken into account.

The inorganic analysis follows.

Some day the relation of the oxygen to the nitrogen of the air in the water must be added as a regular part of the analysis. There is a good deal before us in perfecting and shortening the work.

(Signed) R. A. S.

No. 157. ORDER THEREON, 19th August 1869, No. 1169.

Copies of the foregoing despatch, and of the papers received therewith, will be furnished to the Inspector General of the Indian Medical Department, and to the Sanitary Commissioner, who will be requested to furnish a joint report on the best means of giving effect to paragraph 3 of the despatch of the Secretary of State for India.

(True Extract).

Chief Secretary.

To the Inspector General of the Indian Medical Department.
„ Sanitary Commissioner.

Exd. J. Wright.

India Office,
London, 24th June 1869.

Sanitary,
No.

To His Excellency The Right Honourable The Governor
in Council, Fort St. George.

My Lord,

Para. 1. I forward herewith, for the information of your Excellency in Council, and for the adoption of such measures as may be deemed expedient, copy of a Memorandum by the War Office Sanitary Commission relative to three reports on analysis of Potable Waters of Cantonments, Bengal, by Dr. Macnamara.

2. I also forward copy of a paper of remarks placed at the disposal of the Commission by Dr. Angus Smith, with a view to its communication to the officers engaged in these analyses in India.

3. I desire that your Excellency in Council will issue the necessary instructions for obtaining Reports on Potable Waters in the Presidency of Madras, in accordance with the recommendations of the Army Sanitary Commission.

I have the honour to be,

My Lord,

Your Lordship's most obedient, humble Servant,

Agst

Govt. of Madras.

PUBLIC.

THE INSPECTOR GENERAL OF THE

INDIAN MEDICAL DEPARTMENT.

&c., &c., &c.

Dated August, 19th.

Recd.

Per.

G. O. 19th August 1869, No. 1169.

AUGUST.

Nos. 153-157.

Communicating despatch from the Home Government on the subject, and requesting the Inspector General of Indian Medical Department and the Sanitary Commissioner to furnish a joint report on the best means of obtaining reports on potable waters in this Presidency, in accordance with the recommendations of the Army Sanitary Commission.

No 5. Sanitary
24th June 1869

The
Letter to Fort St George
No 12.

S.D. 1169-19 Aug 4/69.

Forwarding copy of a Memo.
by the War Office Sanitary
Comm. relative to three
reports on analysis of
Potable waters of Cantonments,
Bengal, by Dr. Buchanan.

Read 21st July 1869
24 July

Public Department.

PROCEEDINGS of the MADRAS GOVERNMENT.

Read the following ~~Memorandum~~ Despatch
from the Right Honorable the
Secretary of State for India.

(Here enter 24 June 1869 No. 12)

Order thereon No 1169 - 19 Aug 1/69

Copies of the foregoing
Despatch and of the papers
received therewith will be for-
wished to the Inspector General
Indian Medical Department
and to the Sanitary Commissioner,
who will be requested to fur-
nish a joint report on the
best means of giving effect
to para 3 of the despatch of
the Secretary of State for
India.

MM

To the Supr Genl India Med Dept.
- Sanitary Commr

24 July

Copy sent to the Right Honorable the
Secy of State 23 July 1869.

Handwritten:
No. 1169
27 Sept. 1869

Gort. of 186 } Madras.

Public

To
The Insp. Genl. and Med. Dept.
yes

7 No. 2422.
of fds. 10004.

Dated Aug. 19. } 1869 No.
Recd. 7 1169.

Nos. 156. 157.

Couring. Des. from the Home
Govt on the subject & re-
questing the Insp. Genl. and
Med. Dept. & the Sanitary
Comm. to furnish a joint
report on the best means of
obtaining Reports on Potable
Waters in this Pres. in
accordance with the
recommendations of the
Army Sanitary Comm.