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OF
WATER ANALYSIS
— — —
THRESH

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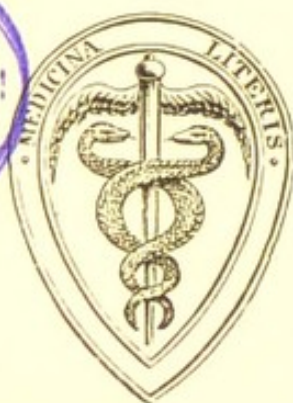


A SIMPLE METHOD
OF
WATER ANALYSIS

ESPECIALLY DESIGNED FOR THE USE OF
MEDICAL OFFICERS OF HEALTH

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LONDON
J. & A. CHURCHILL
7, GREAT MARLBOROUGH STREET
1897



A SIMPLE METHOD OF WATER ANALYSIS

INTRODUCTION

MEDICAL Officers of Health for rural districts find it impossible to efficiently discharge their duties without some knowledge of water analysis. The population in such districts derive their supplies of water from the most varied sources. A single district may contain hundreds of wells, springs, ponds, &c., the water from which is used for domestic purposes by the inhabitants, and cases are almost daily arising in which the Medical Officer of Health desires to know something of the character of a water. He is well aware that it is useless recommending his authority to send a sample to an analyst, so that unless he himself can undertake the work it must remain undone. This is not only my own experience as the Medical Officer to large rural districts, but also my experience as County Medical Officer of Health. In the latter capacity I am continually being consulted on this subject, and more than one of my *confrères* have attended in my laboratory in order to receive instruction in the analysis of water.

Before any new house can be occupied in a rural

district the Medical Officer of Health or sanitary inspector must report to the sanitary authority that there is provided, within a reasonable distance of the house, an available supply of wholesome water, sufficient for the consumption and use for domestic purposes of the inmates of the house. Before such a report can be made the source of the supply must be most carefully examined. For example, if the supply is to be derived from a well, it should be seen that it is properly constructed and protected, that it is sufficiently far from any cesspit, cesspool, or other possible source of pollution, and that any drains running near the well are so laid as to reduce risk of contamination therefrom to a minimum. The yield of water must also be seen to be adequate ; and last, but not least, the water itself should be examined to determine whether it is suitable for domestic purposes. In connection with these new wells it should be remembered that the water drawn therefrom for the first few months will not be so good as the subsequent supply. The cement, brickwork, kerbing, &c., all yield traces of impurity. Sometimes the hardness is increased several degrees by the two former, and the kerb, if of wood, will yield a little organic matter.

I have fully discussed in my work on 'Water and Water Supplies'* the subject of the "Interpretation of Analyses," and it is only necessary here to reiterate the conclusion there arrived at, that it is far more important to examine the source of a water than to analyse it, and that the most carefully made analyses may be seriously misleading if interpreted without the knowledge obtained from such examination.

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Where the possibility of a water becoming contaminated continuously or intermittently is obvious an analysis is unnecessary. Under no circumstances could such a water be pronounced safe. On the other hand, where there are no possible sources of pollution by sewage or animal matters, too great a stress must not be laid upon the analytical results, even if a little organic matter be found to be present. It is well also to remember that many of the largest epidemics of typhoid fever which have occurred during recent years were caused by the consumption of specifically infected water which eminent chemists and bacteriologists had pronounced to be pure; and that large numbers of particularly healthy districts, districts remarkably free from typhoid fever and diarrhoeal diseases, are entirely dependent upon supplies which most analysts would condemn as grossly polluted and unfit for domestic purposes.

In the very great majority of instances the simple method of analysis herein described, together with an examination of the source, will give the Medical Officer of Health all the information necessary for him to pronounce upon the suitability of a water for domestic purposes. The processes require no specially fitted laboratory, and only the simplest possible apparatus. In fact, both chemicals and apparatus can be packed in a small hand-bag, and the analysis conducted in the neighbourhood of the well or other source of supply. Moreover a pint of water is abundant for the analysis, hence the collection of samples is greatly facilitated.

The chemicals used are in the form of soloids, each containing exactly the requisite quantity. They dissolve readily; and with very little experience very accurate results can be obtained.

The results obtained in the quantitative tests I express in grains per gallon, as being best generally understood. In the analysis 70 c.c. of water is used because this quantity contains 70,000 milligrams, and the number of milligrams of any substance contained in this quantity represents the same number of grains in one gallon of water, since one gallon weighs 70,000 grains.

The reagents used must, of course, be thoroughly reliable as to both strength and purity, and the "soloids" made for me by Messrs. Burroughs, Wellcome & Co., from my own formulæ quite fulfil these conditions. Upon analysis I have found them exceedingly uniform in composition, and in every way satisfactory. This firm also has fitted up small cabinets containing the whole of the chemicals, tubes, &c., which they supply at a reasonable charge.

In conclusion, I may add that the process recommended has been thoroughly tested in my laboratory, the results obtained by it being compared with those obtained by more elaborate processes.

JOHN C. THRESH.

CHELMSFORD; *December*, 1896.

REAGENTS REQUIRED

Nessler solution, capsules of.

Soloids of silver nitrate, each corresponding to 2 milligrams of chlorine.

Soloids of potassium chromate.

Soloids of acid sulphate of sodium.

Soloids of potassium iodide and starch.

Soloids of zinc dust.

Soloids of soap, each corresponding to 5 milligrams of calcium carbonate.

Soloids of potassium ferrocyanide.

Soloids of potassium permanganate, each corresponding to .10 milligram of oxygen.

APPARATUS REQUIRED

100-c.c. boiling flask and cork.

100-c.c. tall graduated cylinder.

Small nickel evaporating dish.

Three glass cylinders holding about 100 c.c. each.*

Stirring rods. Tripod. Wool mop for cleaning tubes.

Spirit lamp. Small funnel and filter-paper.

120-c.c. stoppered bottle.

* The bottoms of these cylinders must be flat or concave; if convex the soloids wedge in the angle and dissolve with difficulty.

DIRECTIONS FOR EXAMINING A SAMPLE OF DRINKING-WATER

1. *Colour and turbidity*.—Fill the 100-c.c. cylinder with the water and place it upon a sheet of white paper. Look down the tube, and note the colour and turbidity if any.

2. *Odour*.—Place in the small flask 70 c.c. of water. Warm slightly over the spirit lamp, then cork tightly and shake vigorously. Remove the cork quickly, apply the nose, and note any odour which may be apparent. If the water be now boiled gently for a few minutes the production of a turbidity or precipitate indicates a considerable degree of “temporary” hardness, since the carbonic acid gas holding the carbonate of lime or magnesia or both in solution will have been driven off. The boiling water can then be used for test 11.

3. *Residue left on evaporation*.—Quarter fill the nickel dish with the water, and hold it over the flame of the spirit lamp until it has all evaporated. Note the amount of residue, then heat more strongly and observe to what extent charring occurs. Also record any odour evolved during the charring process.*

4. *Free ammonia*.—To 100 c.c. of the water contained in the 100-c.c. cylinder add a capsule of Nessler solution. With the glass rod break the capsule and mix the contents with the water. Note whether any yellow tint is produced in a few minutes, and, if so, record whether faint, distinct, or very distinct.†

5. *Chlorides*.—Measure 70 c.c.‡ of the water into

* *Vide* Note 1. † *Vide* Note 2. ‡ *Vide* Note 3.

one of the glass cylinders, add a soloid of chromate of potash, and dissolve. The soloids are easily crushed by the end of the glass rod, and dissolve readily when the water is stirred. Then add a soloid of nitrate of silver, dissolve, and mix thoroughly. If no red coloration is produced add another of the soloids, and so on, until the liquid remains red when well mixed. The production of the permanent red colour indicates the end of the reaction. Each soloid corresponds to two grains of chlorine per gallon. Thus, if three soloids were required to produce the red colour, the water contains about six grains of chlorine per gallon. If the third soloid produced no red tint, but the fourth gave a red colour before the whole soloid was dissolved, then the water contains more than six grains and less than eight grains of chlorine per gallon, and seven grains would be the correct amount to record. As the chlorine almost invariably occurs as chloride of sodium, common salt, the amount of the latter can be calculated by multiplying the amount of chlorine found by 117 and dividing by 71, or sufficiently accurately by dividing by .6. Thus, in the water above referred to, the seven grains of chloride correspond to eleven and a half grains of common salt.

6. *Nitrites*.—Take about 70 c.c. of the water in one of the tubes, dissolve therein one soloid of compound potassium iodide, add a soloid of acid sulphate, and dissolve. Note whether any blue colour develops within five minutes, and record whether faint, distinct, very distinct or dark blue. If no blue colour develops in five minutes, nitrites are absent.* The blue colour, if produced, will be proportionate to the amount of nitrites present.

* *Vide* Note 4.

7. *Nitrates*.—If no colour was produced in five minutes add a soloid of zinc, crush, and stir for one or two seconds. Again allow to stand five minutes and note whether a blue colour is developed, and how rapidly. The rapidity with which the coloration is produced and the depth of tint is proportionate to the amount of nitrates present. The results when the nitrates are accurately estimated are usually expressed in grains of nitric nitrogen per gallon. With under one tenth of a grain of nitric nitrogen per gallon a very faint blue develops in about one minute, and is still pale at end of five minutes. With half a grain per gallon a blue tint is evident in four or five seconds, and becomes very distinct in one minute. With one grain per gallon a blue tint is evident in four or five seconds, and the liquid a dark blue at the end of one minute. With two grains and upwards the blue tint appears immediately, on stirring rapidly becomes very dark, or may acquire a green tint. If a blue colour is developed in Experiment 6 the detection of nitrates is rendered more difficult. Fortunately, when nitrites are present the detection and estimation of nitrates is of much less importance. If the nitrates are present in excessive quantities, however, they can in many cases be detected by taking two tubes, each containing 70 c.c. of water, and adding to each a soloid of compound potassium iodide and of acid sulphate. To one then add immediately a zinc soloid. The presence and relative quantity of nitrates will be indicated by the difference in the rapidity with which the blue colour develops, and the difference in depth of tint at the end of five minutes.*

* *Vide* Note 5.

8. *Hardness*.—Measure 70 c.c. of the water into the stoppered bottle, add a soloid of soap, and shake vigorously. If a persistent lather is produced when the soloid is dissolved, the hardness of the water is under four degrees. If no lather is produced, add another soloid and shake. If now a lather forms, the hardness is over four and under nine degrees. If a third soloid is required, the hardness is over nine and under fourteen degrees. If a fourth, it is over fourteen and under eighteen degrees.* If the hardness is chiefly temporary, that is, removable by boiling, the water boiled in the flask for a few minutes in Experiment 1 will already have revealed it. If nothing is deposited, the hardness is entirely permanent; if there is a deposit, the hardness is partially or entirely temporary.

9. *Lead*.—To 70 c.c. of the water in a glass tube add a soloid of chromate of potassium, dissolve, and allow to stand. A yellow turbidity gradually developing indicates the presence of lead. With one tenth of a grain per gallon the turbidity is just visible at the end of half a minute when the tube is held over a piece of black paper or cloth. With half a grain per gallon a very distinct turbidity develops in a few seconds. The greater the turbidity the greater the amount of lead present.

10. *Iron, zinc, and copper*.—To 70 c.c. of water add a soloid of acid and one of ferrocyanide of potassium; if a turbidity is produced zinc is present. One twenty-fifth of a grain of zinc per gallon can be detected by this reaction. When one tenth of a grain is present the opalescence is visible in two or three minutes; with one grain the water becomes turbid in a few seconds. If a blue colour is developed the water

* *Vide* Note 6.

contains a trace of iron. If a reddish-brown tint is produced copper is present.

11. *Oxygen absorbed*.—Measure 70 c.c. of water into the glass flask, and add one soloid of acid sulphate and one of permanganate of potassium. Place over flame of spirit lamp, and raise to boiling-point. Keep simmering for fifteen minutes, adding a permanganate soloid from time to time if the pink colour disappears. Each soloid corresponds to .10 grain of oxygen absorbed by the organic matter in one gallon of water.*

The results thus obtained should be entered on a form similar to those appended hereto.

N.B.—The greatest care should be taken to keep all the apparatus used scrupulously clean, and to rinse each with the water to be examined immediately before use. Turbid waters must be filtered before applying Tests 4, 9, and 10.

INTERPRETATION OF ANALYTICAL RESULTS

1. *Colour*.—A pure water should be practically colourless viewed in a column about six inches deep, or at most have a faint bluish tint. A yellowish or green tint is strongly suggestive of pollution. A peaty water will have a brown tint; but peat alone, unless in excessive quantity, is not deleterious. Certain waters containing much oxidised sewage matters as indicated by an excessive amount of nitrates and chlorides, may be quite free from colour. *Turbidity*.—A pure water will be quite bright and clear. If there is any turbidity its cause should be ascertained.† A water from any source which be-

* *Vide* Note 7.

† *Vide* Note 8.

comes turbid after heavy rain is almost certainly liable to pollution, and should be considered dangerous.

2. *Odour*.—Pure water has no odour. If when warmed and shaken an odour is perceptible, pollution is indicated. Exceptions.—A peaty water has a slight characteristic odour. Some waters derived from beneath the boulder clay have a faint odour of sulphuretted hydrogen (rotten eggs). Rain water when carefully collected has only a very faint odour. As usually collected, however, it has a more marked odour, but it is then impure.

3. *Residue left upon evaporation*.—A good potable water, when evaporated carefully to dryness, leaves only a very small amount of perfectly white residue, which undergoes little or no change when ignited. If organic matter is present the residue may have a brown tint, and will char when strongly heated. Charring, therefore, indicates impurity, especially if the charring be accompanied by a disagreeable odour. Exceptions.—A water containing organic matter, if accompanied by much nitrates, may not char. Peaty water also gives a residue which chars.

4. *Free ammonia*.—Nearly all waters contain a trace of ammonia, but not sufficient if pure to be detected by this test. If, therefore, the addition of Nessler's solution produces a yellow colour, the water is almost certainly impure. Sewage matter is especially prone to yield ammonia. Exceptions.—Rain water almost invariably contains enough ammonia to give a yellow coloration with Nessler reagent. Occasionally other waters, which have been in contact with metal pipes or cisterns (lead, zinc, or iron), contain an excess of ammonia produced by the reduction of some of the nitrates in the water by the metal. In such a case a trace of

the metal will always be detected. If no metal is present the ammonia is almost certainly derived from putrefying organic matter, and the water must be regarded with the gravest suspicion.

5. *Chlorine*.—All waters contain chlorides, but a quantity which would condemn absolutely a water from one source may be without significance in a water from another. No hard and fast line can be drawn, and the statements made in certain textbooks that water containing over a given amount of chlorine is impure are utterly absurd. No inference can be drawn from the amount of chlorine present unless the analyst knows how much is yielded by a water of known purity from an exactly similar source. If, for instance, wells sunk in a certain patch of gravel or other stratum far from any possible source of pollution yield only from two to four grains of chlorine per gallon, and another well in the same stratum but in proximity to a drain or cesspit yields much higher results, pollution with sewage matter is strongly indicated. (Urine contains much common salt.) As a very general rule, high chlorides with an excess of nitrates indicates more or less recent sewage pollution.

If the water contains a large quantity of chlorides and nitrates, and at the same time contains organic matter, as indicated by the charring of the ignited residue (3), and by the oxygen consumed (11), the pollution is recent and especially dangerous.

6. *Nitrites*.—Sewage undergoing decomposition usually contains nitrites, and their presence always indicates the necessity for very careful examination. Like ammonia, nitrites may be produced from nitrates by the reducing action of metals. If, therefore, a trace of lead, zinc, or iron is detected in the

water, the presence of nitrites may have no further significance ; but if no trace of these metals be discovered the water must be regarded with suspicion.

7. *Nitrates*.—Nitrates are derived from organic matter by oxidation, and chiefly from that of animal origin, such as manure or sewage. The nitrates in themselves are perfectly harmless, but if in excess and accompanied by unoxidised organic matter (3 and 11) they indicate dangerous pollution. The remarks made with reference to chlorine apply equally to nitrates. Half a grain of nitric nitrogen per gallon has been suggested as the limit of permissibility, but in waters from some sources this would be an abnormally high amount, and indicate pollution ; whilst in waters from other sources, especially in agricultural districts where the subsoil is porous, larger quantities are present, and yet the water is hygienically good. In any case much over one grain per gallon renders the water open to grave suspicion.

8. *Hardness*.—One degree of hardness corresponds to one grain of carbonate of lime per gallon. Waters with a hardness not exceeding four degrees are very soft ; if over four but not exceeding nine, moderately soft ; if over nine but not exceeding fourteen it may be called hard ; if over fourteen and not exceeding twenty-four, very hard ; whilst waters exceeding twenty-five degrees must be considered excessively hard. Waters under fourteen degrees of hardness are best suited for domestic purposes, and above this degree the water is less and less suitable as the hardness increases. Hardness may be permanent or temporary. The temporary hardness is removed by boiling because the carbonic acid gas, keeping the carbonate of lime in solution, passes off with the steam, and the lime is thrown out of

solution, usually being deposited as a "fur" on the sides of the containing vessel (vide test 2). In a permanently hard water the hardness is usually due to sulphate of lime, and this salt is not deposited on boiling. A permanently hard water is more objectionable than one in which the hardness is merely due to carbonate of lime.

9. *Lead*.—This metal need only be sought for when ammonia or nitrites are present, and in very soft waters. Waters containing more than one or two grains of carbonate of lime per gallon cannot act upon lead. The slightest trace of this metal is a grave indication of danger. A water which is capable of attacking lead will contain more or less of that metal according to the time it has been in contact with the piping or cistern from which the lead is being dissolved.

10. (a) *Zinc*.—Zinc is usually derived from the surface of galvanised iron pipes or tanks. Its presence is decidedly objectionable, though no serious ill effects are recorded from the use of waters containing traces of this metal.

(b) *Iron*.—Traces of iron occur in many natural waters, but sometimes the metal is taken up from the pipes or cisterns. If present in more than very minute traces it may possibly cause constipation among those who habitually drink it. It generally imparts an inky taste to the water, and iron-marks clothes if used for laundry purposes. For these reasons it is objectionable.

(c) *Copper*.—This is very rarely met with, and is only referred to because the reagent used happens also to be the best test for the presence of this metal.

11. *Oxygen absorbed*.—The amount of oxygen absorbed by the boiling water depends, in the absence

of nitrites and ferrous salts,* upon the quantity and nature of the organic matter in solution. Definite standards cannot be fixed, but the following may be accepted as useful guides.

A water which absorbs less than .05 grain of oxygen per gallon will probably be of a high standard of purity.†

A water which absorbs more than .05 grain and less than .10 is probably good.

A water which absorbs more than .10 grain and less than .20 is suspicious.

A water which absorbs more than .20 grain is probably polluted.

Exception.—A peaty water may absorb much more than the above amount of oxygen. Such waters, however, decolourise the permanganate very slowly and continuously during prolonged boiling.

A correct interpretation of the results of analyses cannot be arrived at without some knowledge of the source of the water except in the case of highly polluted waters. If the analysis reveals nothing suspicious, and the source is such that contamination, either continuous or occasional, is practically impossible, then the water may be passed as safe. If there is anything suspicious in the surroundings a very guarded opinion must be given. Where the analytical results lead to suspicion a thorough investigation of the source must in every case be

* These substances are very rarely present in such quantities as to appreciably affect the amount of oxygen absorbed. When such is the case the water is almost certainly unfit for domestic purposes. Nitrites and iron rapidly decolourise the permanganate in the cold. Organic matter, unless present in very large amount (very impure waters), decolourises it very slowly unless the solution be heated.

† *Vide* Note 9.

recommended,—as, for example, the examination of the inside of a well, opening the ground around to examine the drains, &c. If there is any possibility of pollution the water should be considered unsafe. Those desiring further information with reference to this subject should consult the author's work on 'Water and Water Supplies.' The following abstract of a paper communicated by me to the British Medical Association in 1894 may be studied with advantage.

"Of the numerous substances found in potable waters it is now generally admitted that only those of organic origin are a serious source of danger, and that by far the greatest risk is incurred in using water liable to contain certain living organisms, which, when introduced into the system, are capable of producing specific disease. Of the presence or absence of such organisms chemical analysis can give us no information. The presence of organic matter may be chemically demonstrated, but inasmuch as its nature, whether poisonous or innocuous, is beyond the power of the analyst to reveal, it is obvious that a mere chemical analysis may often be worthless or even misleading. This point cannot be too strongly emphasised, since the popular impression that the chemist, by performing a few mysterious experiments with a water in his laboratory, can pronounce at once whether it is pure or impure, safe or dangerous, is shared alike by the ignorant and the learned, and must be dispelled. All the determinations of the analyst are of more or less importance as an index of the degree of pollution, recent or remote, but their real value can in very few cases be assessed without some previous knowledge of the source of the water. The inorganic constituents can easily be determined,

and whether, either in quality or quantity, they are objectionable, an opinion may safely be expressed. They are, therefore, chiefly of interest to us in so far as their presence tends to throw light upon the source of the organic matter which in greater or lesser quantity is always present. Only under certain circumstances has the determination of chlorides any significance, and pure water from some sources may contain a larger amount of chlorides than the same water when contaminated. The importance of an estimation of nitrates was for a long time undervalued; at the present time the tendency is to greatly exaggerate it. The amount of nitrates which would condemn a water from one source may be absolutely without significance in a water from another. It is often taught that the presence of nitrites is conclusive evidence of the dangerous character of a water, yet these compounds may be derived from the most innocent sources, as by the reduction of nitrates by metals, cement, new brickwork, &c. Erroneous conclusions may also be drawn from the determination of phosphates, free oxygen, ammonia, and albuminoid ammonia. In very many instances chemical analysis has failed to find such evidence of pollution as would justify the analyst in condemning a water, yet these very waters have caused more or less serious outbreaks of disease. Although a mere chemical examination cannot guarantee that a water is pure and can be used without risk, yet it can very frequently reveal to us impurity and danger. All so-called standards should be abandoned as absurd, and the opinion as to whether a water is dangerous or safe should be based upon a full consideration of all the important factors.

“ With the discovery of the fact that such diseases

as typhoid fever and cholera are due to the introduction into the system, not of dead organic matter but of living organisms, faith in the chemical analysis of water began to be shaken. When, still more recently, the actual microbes causing these diseases had been identified, and processes had been devised for isolating them from the multitude of other organisms found in water, it seemed as though the examination of water for sanitary purposes had passed from the domain of the chemist into that of the bacteriologist. Further experience, however, is teaching us that the results of bacteriological examinations may be as misleading as those of chemical analyses. The cholera bacillus could not be demonstrated in the water poisoning the inhabitants of Hamburg and Altona; neither could the typhoid bacillus be found in the water-supply which last year produced the epidemic in Worthing. Bacteriology, like chemistry, may tell us something of impurity and hazard, but neither can be depended upon to determine with certainty whether a water is actually injurious to health. *The possibility of occasional pollution is a point too often overlooked, yet it is to such accidental pollution that outbreaks of disease are most frequently attributed, and of the liability to this the examination of samples of water, prior to the occurrence of the contamination, may tell us little or nothing.* The danger of such pollution does not, unfortunately, vary with the amount of any constituent found in the water, and a source yielding a water of great chemical and bacterial purity may be more liable to occasional fouling than a source yielding water containing excessive quantities of chlorides and nitrates, unoxidised organic matter, or even living organisms. Bacteriological and microscopical examinations, as well as chemical analyses, must there-

fore always be associated with a thorough investigation of the source of the water to determine the possibility of contamination, continuous or intermittent, and a guardedly expressed opinion given only after a full consideration of the bearing of the one upon the other. When a water is known to be fouled by sewage, or known to be liable to such pollution, any form of examination is superfluous; and as neither bacteriology nor chemistry can be depended upon to prove that a water is free from all dangerous pollution, such examinations are, in many cases, useless."

The form used in the subjoined reports will be found very convenient for all ordinary purposes. The waters reported upon are typical, and a careful study of (*a*) the source of each sample, (*b*) the analytical results, and (*c*) the reports based thereon, will be of great aid in enabling correct interpretations of other analyses to be made. At the end of the series of reports a table is given showing the results obtained when the same samples were submitted to the usual analytical processes. Every one who has made a special study of water analysis will admit that the conclusions drawn from the simple method herein described are in every respect confirmed by the more complicated process. All the analyses given were made by myself and assistants, the two series being conducted independently. Many others have been made, but those quoted are sufficient to prove the reliability of the new methods and to serve as examples. Nos. 21 and 22 are inserted to show that the processes are equally applicable for the examination of sewage or sewage effluents.

NOTES

1. The nickel dish can easily be kept bright by cleaning with soap and Bath brick, or by using "Monkey" soap.

2. Waters which contain more than a trace of magnesia give a precipitate with the Nessler solution. The precipitate becomes flocculent in a few minutes, and then slowly settles to the bottom of the tube. Such waters will usually be found to be very hard, and are generally objectionable for domestic purposes.

3. When a water contains excessive quantities of chlorides or nitrates, or has a hardness of over fourteen degrees, it may sometimes be desirable to take 20 c.c. or 35 c.c. only for analysis, diluting up to 70 c.c. with pure distilled water. A simple calculation will give the results in grains per gallon.

4. All waters give a faint blue colour with this test if allowed to stand long enough. A five minutes' limit is given, since an infinitesimal trace of a nitrite will give a blue colour in this time.

5. A better method of estimating nitrates in the presence of nitrites is to add a soloid of acid sulphate to 70 c.c. of the water, and boil in the flask till the volume is reduced to about half. By this means the nitrous acid is driven off, and the water can be diluted with distilled water to 70 c.c., and when quite cold examined for nitrates.

6. If the hardness of a water is in part due to the presence of magnesia salts this will have been already indicated by Test 4 (*vide* Note 2). Care must be taken in all cases to work to a good lather, which persists for four or five minutes, and not to mistake the curd which occurs with magnesia water for lather. As it requires an amount of soap corresponding to 1° of hardness to produce this lather, the 1° is always de-

ducted from the amount indicated by the soloids. Thus one soloid equals five degrees of hardness, but corrected this becomes four ; two tabloids ten degrees, or corrected nine, &c.

7. Some waters, always of a suspicious or dangerous character, do not completely decolourise the permanganate, but acquire a decided yellow tint. The soloids must be added until a decided pink tint remains.

8. The microscope is often of extreme value in determining the nature of sedimentary matter. By allowing 50 to 100 c.c. of the water to stand all night in a tall cylinder, then carefully pouring off the water, leaving only a few drops with the residue, its nature can easily be investigated. A small portion can be ignited on the nickel dish to ascertain whether it is organic or inorganic. A minute drop of the mud, if mixed with a drop of dilute acid, may effervesce, generally indicating the presence of carbonate of lime. Another minute drop examined under a microscope with $\frac{1}{4}$ -inch objective will probably reveal more than the observer can recognise or interpret, unless he has had considerable experience. Decaying organic matter, vegetable or animal, is objectionable. Fibres of silk, wool, cotton, linen, starch granules, epithelial scales, fatty matter, &c., are suggestive of sewage. The larger infusoria, anguillulæ, &c., chiefly abound in pond and river water containing much organic matter.

9. A very pure water exerts little effect upon the permanganate. The marked pink colour produced by the solution of one soloid in 70 c.c. is barely affected by the fifteen minutes' boiling. Such waters are classed as absorbing not more than .05 grain of oxygen per gallon.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM RAIN-WATER TANK

No. 1. October 26th, 1896

Source and possibility of contamination.—Collected on a clean surface. Not filtered. No possibility of contamination. A fair sample of water collected from a roof with a rain-water “separator.”

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Faint blackish-yellow tint. *Turbidity.*—Very slight.
2. *Odour.*—Faint, *sui generis*.
3. *Residue left on evaporation.*—Very slight. Signs of charring when ignited.
4. *Free ammonia.*—Large trace.
5. *Chlorine.*—About $\frac{1}{2}$ a grain per gallon. *Equivalent of common salt.*—Under 1 grain per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—None.
8. *Hardness.*—About 2°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Over .15 grains per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that the water is admirably adapted for domestic purposes if always as carefully collected. It must be remembered that such waters act energetically on lead, zinc, and iron. Earthenware or slate cisterns should be used for storage, and block-tin pipes for distribution of that portion used for drinking and culinary purposes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM THE ABERYSTWITH PUBLIC SUPPLY

No. 2. July 20th, 1896

Source and possibility of contamination.—Collected on the sides of Plynlimmon. Surface of collecting area chiefly bare rock. No cultivated ground.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Faint brown tint. *Turbidity.*—None.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Very little indeed. Did not char on igniting.
4. *Free ammonia.*—None.
5. *Chlorine.*—Mere trace (under one grain). *Equivalent of common salt.*—About 1·6 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—None.
8. *Hardness.*—Under 1°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—About ·15 grain per gallon.

From the report upon the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is an exceedingly pure water, and well adapted for all domestic purposes.

(For the action of such water on metals *vide* Report 1.)

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM PUDSEY PUBLIC MAINS

No. 3.

November 3rd, 1896

Source and possibility of contamination.—A moorland surface water which, after collection, is filtered through chalk to neutralise any acidity and prevent action upon lead. The sample was drawn first in the morning after standing all night in a lead pipe 80 feet long.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Decided brown tint.
Turbidity.—Faint, a little fine flocculent matter.
2. *Odour.*—Faint, peaty.
3. *Residue left on evaporation.*—Scarcely visible ; turned brown when ignited.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—About 1 grain per gallon. *Equivalent of common salt.*— $1\frac{1}{2}$ grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—A most minute trace.
8. *Hardness.*—About 4° .
9. *Lead.*—Minute trace, under $\frac{1}{10}$ grain per gallon.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at $212^{\circ} F.$* —Between $\cdot 25$ and $\cdot 30$ grain per gallon.

From the report upon the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is well adapted for all domestic purposes. It has still a very slight action upon lead, and if the use of lead pipes is continued care should be taken to run to waste any water which has been standing in the pipes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM DR. W.'S WELL, WRITTLE

No. 4. October 22nd, 1896

Source and possibility of contamination.—A shallow well sunk in gravel subsoil. Drainage around good. No obvious source of pollution.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Colourless. *Turbidity.*—Quite clear and bright.
2. *Odour.*—None.
3. *Residue left on evaporation.*—White residue. Did not char when heated. A marked deposit of lime salts on boiling.
4. *Free ammonia.*—No obvious trace.
5. *Chlorine.*—About 3 grains per gallon. *Equivalent of common salt.*—About 5 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—About .25 nitric nitrogen per gallon.
8. *Hardness.*—About 14°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under .05 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is an exceedingly good sample of shallow well water, and is well adapted for all domestic purposes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM ONE BRIDGE COTTAGES

No. 5.

October 21st, 1896

Examination of the source and possibility of contamination.—Derived from a very shallow well. There is a filthy ditch and a privy cesspit within five yards of the well.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Decidedly yellow. *Turbidity.*—Very faint opalescence.
2. *Odour.*—None perceptible.
3. *Residue left on evaporation.*—Pale brown in colour, and charred when ignited.
4. *Free ammonia.*—No appreciable trace.
5. *Chlorides.*—About 8 grains per gallon. *Equivalent to common salt.*—13 grains.
6. *Nitrites.*—None.
7. *Nitrates.*—Very excessive (over 2 grains per gallon of nitric nitrogen).
8. *Hardness.*—About 18°.
9. *Lead.*—None.
10. *Iron or zinc.*—None.
11. *Oxygen absorbed.*—Over .20 grain per gallon.

From the examination of the source from which this water is derived, and from the results obtained by chemical analysis, I am of opinion that it is polluted and quite unsafe for use for domestic purposes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM STOCK PARISH PUMPNo. 6. *October 20th, 1896*

Source and possibility of contamination.—Shallow well in gravel subsoil, sunk on the "Green." Surrounded by houses without proper sewers. Cess-pools and cesspits numerous.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Faint yellow tint. *Turbidity.*—Distinct opalescence.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Distinct; charred when ignited, and gave off fatty odour.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—About 4 grains. *Equivalent of common salt.*—About 7 grains.
6. *Nitrites.*—None.
7. *Nitrates.*—Between .5 and 1 grain N per gallon.
8. *Hardness.*—About 12°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—.15 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it cannot be considered a safe potable water. A better source of supply should be selected if possible.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM PRIVATE PUMP IN HAVERHILL (SUFFOLK)

No. 7.

October 30th, 1896

Source and possibility of contamination.—Typhoid fever occurred amongst the users of this water some time ago. Since then the well and surroundings have been made as safe as possible. Well in front of cottages. Subsoil chalk.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Clear, bright, and colourless. *Turbidity.*—None.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Distinct, quite white. Did not char when ignited.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—About 2 grains per gallon. *Equivalent of common salt.*—About 3 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—About .5 grain per gallon.
8. *Hardness.*—About 23°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under .05 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is of as good a quality as can be obtained from such a source. I cannot say, however, that its use is absolutely unattended by risk. It would be safer to supply the cottages with water from the public mains.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM SHALLOW WELL IN WIDFORD

No. 8. October 2nd, 1896

Source and possibility of contamination.—Sunk in brick earth and gravel in garden. No obvious drainage defects.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Slight yellow tint.
Turbidity.—None.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Distinct, greyish, and turned brown when ignited.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—About 10 grains per gallon. *Equivalent of common salt.*—17 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—About 2 grains per gallon.
8. *Hardness.*—About 20°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Over 2 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is polluted with manurial matters which have penetrated the subsoil and reached the ground water. I do not regard it as safe for domestic purposes, and recommend that steps be taken to close the well.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM SHALLOW WELL AT ALTHORNE

No. 9.

August, 1896

Source and possibility of contamination.—Well in garden, a considerable distance from any house or drain.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Colourless. *Turbidity.*—Clear.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Greyish. Did not char when ignited.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—About 9 grains per gallon. *Equivalent of common salt.*—About 15 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—About .3 grain per gallon.
8. *Hardness.*—About 14°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under .15 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it contains a trace of manurial matter derived from the garden. Unfortunately no other source is available. The well should be opened and examined, and if of uncemented brick, the sides should be rendered impervious to a depth of six or eight feet. This would almost certainly improve the quality of the water, and reduce the risk from using it to a minimum.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM ABYSSINIAN TUBE WELL, WRITTLE

No. 10. July 10th, 1896

Source and possibility of contamination.—Tube driven to a depth of about 20 feet in brick earth and sand. Situated in a field. No house or drain within 200 yards.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Faint blue tint. *Turbidity.*—Contained a little fine sand.
2. *Odour.*—None.
3. *Residue left on evaporation.*—White, and unaffected by heating.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—About 2 grains per gallon. *Equivalent of common salt.*—3 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—Between .5 and 1 grain N per gallon.
8. *Hardness.*—Just under 14°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under .05 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that this water is well adapted for all domestic purposes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM "THE BARRACKS"

No. 11.

October 20th, 1896

Examination of the source and possibility of contamination.—A spring arising in a hole sunk at the edge of a ditch receiving sewage from the cottages called "the Barracks." This ditch is foul, and a moderate rain must wash the sewage into the dipping place.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Free from colour.
Turbidity.—Perfectly bright.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Very little ; quite white ; did not char.
4. *Free ammonia.*—No appreciable quantity.
5. *Chlorides.*—Under 4 grains per gallon. *Equivalent to common salt.*—Less than 7 grains.
6. *Nitrites.*—None.
7. *Nitrates.*—Not excessive. About .5 grains per gallon of nitric nitrogen.
8. *Hardness.*—Between 14° and 19°. Almost entirely removed by boiling.
9. *Lead.*—Not tested for. Could not be present.
10. *Zinc and iron.*—Not tested for. Could not be present.
11. *Oxygen absorbed.*—Under .05 grain per gallon.

From the examination of the source from which this water is derived, and from the results obtained by chemical analysis, I am of opinion that this water, though dangerously liable to pollution, is of good quality, and suitable for domestic purposes. Until the spring is properly protected, however, it should not be used.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM PUBLIC MAINS, SOUTHMINSTER

No. 12. *October 20th, 1896*

Source and possibility of contamination. — Derived from springs arising at edge of extensive gravel patch. Ground highly cultivated. No houses or drains near.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Colourless. *Turbidity.*—Quite clear.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Very little. White, and not affected by igniting.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—About 2 grains per gallon. *Equivalent of common salt.*—Under 3·5 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—About 1 grain N per gallon, a little under.
8. *Hardness.*—About 12°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under ·05 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is admirably adapted for all domestic purposes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM THE GREAT BADDOW PUBLIC SUPPLY

No. 13.

November 1st, 1895

Source and possibility of contamination.—A spring water rising at the edge of an extensive gravel patch. Surface cultivated ground. Surroundings of spring well protected.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Very faint bluish tinge. *Turbidity.*—Quite bright.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Slight, white, did not char. No deposit on boiling.
4. *Free ammonia.*—No evidence of.
5. *Chlorine.*—About 2 grains per gallon. *Equivalent of common salt.*—About 3 grains.
6. *Nitrites.*—None.
7. *Nitrates.*—About .5 grain nitric nitrogen per gallon.
8. *Hardness.*—9°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under .05 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is well adapted for all domestic purposes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM PUBLIC SUPPLY AT DANBURYNo. 14. *November 4th, 1896*

Source and possibility of contamination.—Derived from a spring on an extensive common, arising from a large patch of gravel. Village stands on same patch about half a mile away. Drawn from stand-pipe.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—No colour. *Turbidity.*—None.
2. *Odour.*—None.
3. *Residue left on evaporation.*—White, no charring.
4. *Free ammonia.*—No evidence.
5. *Chlorine.*—2 grains per gallon. *Equivalent of common salt.*—About 3 grains per gallon.
6. *Nitrites.*—Minute trace.
7. *Nitrates.*—About 1 grain N per gallon.
8. *Hardness.*—About 5°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—Trace of iron.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under .05 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is well adapted for all domestic purposes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM THE RIVER WID

No. 15.

October 31st, 1896

Source and possibility of contamination.—River flowing through arable land, and receiving sewage from farmhouses, &c., at distant intervals.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Distinct yellow tint.
Turbidity.—Faintly turbid.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Pale brown in colour, and charred when ignited.
4. *Free ammonia.*—No appreciable trace.
5. *Chlorine.*—About $2\frac{1}{2}$ grains per gallon. *Equivalent of common salt.*—About 4 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—About .2 grain N per gallon.
8. *Hardness.*—About 18° .
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—Trace iron.
11. *Oxygen absorbed in 15 min. at 212° F.*—About .25 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that the water is impure, liable to serious contamination, and quite unsafe for use for domestic purposes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM EAST LONDON WATERWORKS CO., WAL-
THAMSTOW MAINS

No. 16. November 4th, 1896

Source and possibility of contamination.—Derived from the river Lea, and filtered before delivery into mains to supply East London.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—No colour. *Turbidity.*—
A little flocculent matter.
2. *Odour.*—None.
3. *Residue left on evaporation.*—White, but charred
slightly on igniting.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—Nearly 2 grains per gallon. *Equiva-*
lent of common salt.—About 3 grains.
6. *Nitrites.*—None.
7. *Nitrates.*—About .3 grains nitric N per gallon.
8. *Hardness.*—14°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Between
.05 and .10 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that the water has not been properly filtered. Such being the case its use cannot be said to be unattended by risk.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM PUBLIC WATER-SUPPLY, SOUTHEND

No. 17.

August 5th, 1896

Source and possibility of contamination.—From bored wells nearly 1000 ft. deep, thoroughly well constructed. Derived from Lower Chalk beds. Apparently no possibility of contamination.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Colourless. *Turbidity.*—Clear and bright.
2. *Odour.*—None.
3. *Residue left on evaporation.*—White, and fusing when ignited.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—About 24 grains per gallon. *Equivalent of common salt.*—About 40 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—Under .1 grain N per gallon.
8. *Hardness.*—2°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—Minute trace of iron.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under .05 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that this is an exceedingly pure water, and well adapted for all domestic purposes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM BORED WELL, GREAT HAYESNo. 18. *October 20th, 1896*

Source and possibility of contamination.—Bored well 300 feet deep, which should yield water similar to No. 17. Top of well covered with rotten sleepers, and surface water can gain access. No house or drains near.

Chemical and Physical Examination.

1. *Colour in 6-in. column.*—Yellowish tint. *Turbidity.*—Slight turbidity.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Brownish residue, charring when ignited.
4. *Free ammonia.*—Reaction obscured by turbidity produced.
5. *Chlorine.*—About 9 grains per gallon. *Equivalent of common salt.*—About 15 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates.*—Very minute trace, much under .1 N per gallon.
8. *Hardness.*—About 40°. Much magnesia.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—About .2 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is a mixture of deep well and surface water. The bore-pipe is probably defective, allowing magnesia water to get in through the clay. It is not fit for domestic use. The well requires thoroughly overhauling and placing in proper repair.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM.....HOSPITAL

No. 19.

October 8th, 1896

Source and possibility of contamination.—This is derived from a public supply of unexceptional quality, but is very soft, and passes through a long length of galvanised iron piping.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Faint bluish tint.
Turbidity.—Clear and bright.
2. *Odour.*—None.
3. *Residue left on evaporation.*—Slight ; did not char when ignited.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—About 2 grains per gallon. *Equivalent of common salt.*—About 3·5 grains per gallon.
6. *Nitrites.*—Trace.
7. *Nitrates.*—Nearly 1 grain N per gallon.
8. *Hardness.*—About 5°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—Trace of zinc and iron.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under
·1 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is of good quality, but as it evidently acts upon zinc and iron care should be taken to run to waste any water which has been standing in the pipes.

EXAMINATION OF A SAMPLE OF DRINKING-WATER
FROM BURNHAM PUBLIC SUPPLYNo. 20. *October 20th, 1896*

Source and possibility of contamination.—Drawn from main. Supply derived from subsoil. Cultivated ground near collecting tank, but no houses or drains.

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Faint bluish tint. *Turbidity.*—Clear and bright.
2. *Odour.*—None.
3. *Residue left on evaporation.*—White, not changed by heating.
4. *Free ammonia.*—No evident trace.
5. *Chlorine.*—Under 4 grains per gallon. *Equivalent of common salt.*—About 7 grains per gallon.
6. *Nitrites.*—None.
7. *Nitrates* —About .5 grain N per gallon.
8. *Hardness.*—Nearly 12°.
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—Under .05 grain per gallon.

From the examination of the source of the water herein referred to, and the results obtained by analysis, I am of opinion that it is well adapted for all domestic purposes.

EXAMINATION OF A SAMPLE OF SEWAGE FROM A
SEWAGE FARM, COLLECTED AT END OF MAIN
SEWER

No. 21.

October, 1896

Chemical and Physical Examination.

1. *Colour in 6-in. column.*—Distinctly yellow-brown.
Turbidity.—Contained much flocculent matter.
2. *Odour.*—Strongly urinous.
3. *Residue left on evaporation.*—Voluminous, brown.
Charred when ignited, and an unpleasant odour evolved.
4. *Free ammonia.*—Very abundant.
5. *Chlorine.*—About 8 grains per gallon. *Equivalent of common salt.*—About 13 grains per gallon.
6. *Nitrites.*—Trace.
7. *Nitrates.*—About $\frac{1}{2}$ grain N per gallon.
8. *Hardness.*—About 18° .
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—About 2 grains per gallon.

A typical sample of town sewage.

EXAMINATION OF A SAMPLE OF SEWAGE EFFLUENT
FROM MAIN OUTFALL INTO RIVER, FROM SAME
SEWAGE FARM

No. 22.

October, 1896

Chemical and Physical Examination

1. *Colour in 6-in. column.*—Distinctly yellow. *Turbidity.*—Little flocculent matter.
2. *Odour.*—Slightly urinous.
3. *Residue left on evaporation.*—Distinct, brown. Charred when ignited, and gave off unpleasant odour.
4. *Free ammonia.*—Much.
5. *Chlorine.*—About 6 grains per gallon. *Equivalent of common salt.*—10 grains per gallon.
6. *Nitrites.*—Trace.
7. *Nitrates.*—About $\frac{1}{2}$ grain per gallon.
8. *Hardness.*—About 18° .
9. *Lead.*—None.
10. *Zinc, iron, and copper.*—None.
11. *Oxygen absorbed in 15 min. at 212° F.*—1.3 grains per gallon.

From the results obtained by analysis, I am of opinion that this sample of effluent is very unsatisfactory. The odour, the character of the residue left on evaporation, the large amount of free ammonia, and the oxygen required for oxidation prove that oxidation and purification are very incomplete.

*Results obtained by the Ordinary Methods of
by the Simple Method*

| Reference number. | In grains per gallon | | | | Hard- |
|----------------------|----------------------|-----------|-----------|------------|-------|
| | Nitric nitrogen. | Chlorine. | Nitrites. | Temporary. | |
| 1 | ·0 | ·5 | None | ·0 | |
| 2 | ·0 | ·5 | „ | ·5 | |
| 3 | ·01 | 1·0 | „ | 1·0 | |
| 4 | ·18 | 2·9 | „ | 14·0 | |
| 5 | 2·6 | 8·6 | „ | 18·0 | |
| 6 | ·7 | 4·3 | „ | 6·0 | |
| 7 | ·48 | 1·8 | „ | 18·0 | |
| 8 | 2·3 | 10·0 | „ | 12·5 | |
| 9 | ·33 | 8·6 | „ | 10·0 | |
| 10 | ·70 | 1·9 | „ | 7·5 | |
| 11 | ·49 | 3·5 | „ | 15·0 | |
| 12 | ·91 | 2·0 | „ | 1·5 | |
| 13 | ·75 | 2·0 | „ | 2·5 | |
| 14 | ·93 | 2·0 | Trace | 2·5 | |
| 15 | ·17 | 2·6 | None | 12·5 | |
| 16 | ·29 | 1·7 | „ | 12·5 | |
| 17 | ·07 | 22·3 | „ | 2·5 | |
| 18 | ·03 | 8·5 | „ | 32·5* | |
| 19 | ·92 | 2·5 | Trace | 2·0 | |
| 20 | ·87 | 3·5 | None | 7·0 | |
| 21 | ·46 | 7·5 | Trace | — | |
| 22 | ·48 | 6·0 | „ | — | |

* Contains much

Analysis, for comparison with those obtained herein described.

| ness. | Lead, zinc, iron, copper. | Ammonia (in parts per million). | |
|--------|--------------------------------|------------------------------------|----------|
| | | Free. | Organic. |
| Total. | | | |
| 1.5 | None | 1.60 | .10 |
| .5 | " | .00 | .05 |
| 4.0 | Trace lead, $\frac{1}{10}$ gr. | .00 | .04 |
| 14.0 | None | .00 | .06 |
| 22.0 | " | .04 | .60 |
| 11.0 | " | .03 | .14 |
| 22.0 | " | .06 | .04 |
| 21.0 | " | .00 | .20 |
| 13.0 | " | .00 | .17 |
| 12.6 | " | .00 | .03 |
| 16.5 | " | .02 | .09 |
| 6.0 | " | .00 | .02 |
| 9.0 | " | .02 | .05 |
| 5.0 | Trace iron | .02 | .02 |
| 16.0 | " | .10 | .24 |
| 14.0 | None | .00 | .08 |
| 3.5 | M. trace iron | .01 | .03 |
| 41.0* | None | .14 | .25 |
| 5.0 | Trace zinc and iron | .06 | .04 |
| 11.0 | None | .01 | .04 |
| 17.0 | " | 27.5 | 1.96 |
| 17.0 | " | 16.25 | .81 |

magnesium sulphate.



THE
BURROUGHS, WELLCOME & CO.
WATER ANALYSIS CASE.

—◆—
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—◆—

The Case contains all the soloids and apparatus mentioned on p. 7, together with a supply of the Special Report forms recommended by the Author. The front page of the form is used for the analytical results, and a fly-leaf for the report based on the analysis.

Specimen of Report Form recommended by the Author.

EXAMINATION OF A SAMPLE OF DRINKING-
WATER.

From.....

.....189

Source and Possibility of Contamination

Chemical and Physical Examination.

1. Colour in 6-in. column
- Turbidity
2. Odour
3. Residue left on evaporation.....
4. Free Ammonia
5. Chlorine
- Equivalent of Common Salt
6. Nitrites
7. Nitrates
8. Hardness
9. Lead
10. Zinc, Iron, and Copper
11. Oxygen absorbed in 15 min. }
- at 212° F. }

(Address).....

(Date).....189

From the examination of the source of the water
herein referred to, and the results obtained by analysis,
I am of opinion that

(Signed).....

To.....

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