Angell (E.R.)

SANITARY EXAMINATION

OF

DRINKING-WATER.

BY

PROF. EDMUND R. ANGELL,

DERRY, N. H.

Reprint from the Third Annual Report of the N. H. State Board of Health.]

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SANITARY EXAMINATION OF DRINKING-WATER.

The aim of the following article is to furnish every intelligent person with sufficient information to enable him, with trifling expense, to determine approximately the quality of the water which he drinks daily. It is not an easy matter to reduce the operations of water analysis to such simplicity that they may be readily used, and give accurate results; but it is believed that the methods brought foward in these pages, if carefully and patiently applied, will give in most cases reliable information concerning the sanitary condition of water; and it is hoped that the subject is presented in such a way as to be the means of awakening more interest in this very important subject. For when it is considered that three fourths of the human body is water,the need of maintaining the supply from pure sources begins to be realized. It is well known that thirst prostrates one sooner than hunger: the larger portion of the system evidently makes the more important demand. But water is no more necessary to life than pure water is to health. Because persons have drunk questionable water and still live, is no sign that they would not have lived better on pure water: because one survives a dose of poison, is no reason that poison is good, or even harmless.

How much poison is taken into the system from impure water it is difficult to say, but it is certain that experience and science, again and again, have traced sickness and death to this source; and it is reasonable, if badly polluted water causes severe and fatal disease, that slightly impure water may slowly undermine the health by being the cause of a host of ailments and inabilities of body for which the sufferer finds no apparent cause.

Let him who is afflicted in this way turn his attention to the various sanitary conditions of his surroundings, and especially to that of the water he drinks, that he may know whether or not every draught that quenches his thirst shortens his life; and let him who thinks he knows no ill, do the same, to the end that he may live many days free from evil.

Water may be injurious to health because it contains decomposing organic matter, either animal or vegetable, or because it contains some poisonous metal, usually lead.

In examining water, the first thing likely to be noticed is its appearance. Generally, polluted waters have various shades of a yellowish or brownish tint, which vary according to the amount of filth which they contain; but to this there are so many exceptions, that the color is by no means a safe guide. Some peaty waters, and those that contain iron, may have a yellowish or brownish tint, and yet be perfectly healthful. On the other hand, some very badly polluted waters are perfectly clear, and frequently present a better appearance than many pure waters.

The character of a water can seldom be determined from any one indication or test. The accumulated evidence of a number of tests is necessary for the formation of a correct opinion of its quality. Occasionally, from the most accurate and numerous tests that can be made in a fully equipped laboratory, it is impossible to pronounce on some waters, while others are so marked in character that a few tests declare at once what they are.

THE ODOR OF A WATER.

The smell of a water often gives some indication of its character. But it frequently happens that wholesome waters have an unpleasant odor: this is the case with some mineral waters. In clayey districts especially, water which is organically pure may have an objectional odor which is imparted by the clay. The waters of some lakes and rivers which supply some of our large cities, as Boston, New York, and Baltimore, have at times a peculiar "fish-like" odor. It generally begins in summer, but sometimes not until autumn. It is due, probably, to some condition of water plants,—whether to a state of growth, or decay, is uncertain. Growing plants emit odors peculiar to themselves: so it is not necessary to suppose that the odor mentioned arises from decay. However it may be, there is yet no evidence that such water is injurious to the health of those who drink it.

TO DETECT THE SMELL OF WATER.

If the odor is very marked, of course there is no difficulty in perceiving it; when this is not the case, partly fill a clean bottle with the water to be tested, and after shaking it violently, so as to communicate the odor to the air within the bottle, smell of it. If this gives no result, warm the water. To do this so as not to break the bottle, place it in a kettle of cold water, and heat the whole together. Heat expels the gases dissolved in the water so that they may be detected. Finally the odor may be made more apparent by adding a little caustic potash to the water.

THE SUGAR TEST.

An easy and quite reliable test for organic matter in water is this: Add about ten grains of pure granulated sugar to about five ounces of the water to be tested: the bottle should be completely filled, and the stopper tightly fitted, so as to exclude the air. Expose the water to daylight and a temperature of about seventy degrees Fahrenheit. If it contains much organic matter, an abundance of whitish specks will appear within a day or two, floating around in the liquid. Of course the more organic matter there is, the more marked the appearance. These little bodies are best observed by holding the bottle against something black, or by partly shading the farther side of it with the hand. After a while they will group themselves together in bunches, and partly settle to the bottom of the bottle: at length, if the water is very bad, the odor of butyric acid (the smell of rancid butter) becomes perceptible.

CHLORINE.

This is a constituent of common salt, and is very widely distributed in nature. Good water on an average contains perhaps from 0.4 to 1.0 grain of chlorine per gallon. If a water contains more than this amount, it is a strong indication that it has received pollution from cesspools, sink-drains, or the excreta of animals, all of which are highly charged with salt. But some localities, especially those near the sea, contain more salt than others; so that a good water in those districts may contain five, or even ten, grains of chlorine per gallon, for that is the natural amount. Before one could pronounce with some confidence on the sanitary condition of a water from the determination of chlorine alone, it would be necessary to know the average amount of it in the natural waters of the region: hence, if in a single instance a water contains more than the general average, and there are no other indications of impurity, it would be unwise to condemn it. On the other hand, it would be equally unwise to pronounce a water safe if it contains less than the average amount of chlorine; because waters very badly polluted with vegetable matter alone are deficient in chlorine. However, when chlorine is deficient it is certain that there is no contamination from animal matter.

It is possible for waters to contain salt that has come from filth, without containing the filth itself. When this is the case, one of two conditions exists: it may be indicative of a past pollution, or a warning of coming danger. Filth that had previously found access to the well may have undergone complete decomposition, while the salt remains; or filth may be so far from the well that nothing but its salt is washed through the intervening earth into it. Both conditions render the well unsafe, for in the one case another inflow of filth is liable to occur; in the other, the soil may soon become too fully charged with it to retain it all.

THE ESTIMATION OF CHLORINE.

To determine the approximate amount of chlorine, it is necessary to prepare a standard solution of salt. One ounce avoirdupois, 437.5 grains, of pure salt contains 265.5 grains of chlorine. If this be dissolved in 17.7 fluid ounces of water, each drop of the solution, reckoning 480 drops to the ounce, ought to contain $\frac{1}{32}$ grain of chlorine, since $(265.5 \times 32) \div 480 = 17.7$.

Weigh, as carefully as possible, one ounce avoirdupois of best table salt; dissolve it in eighteen ounces of clean rain-water. This solution will contain very nearly $\frac{1}{32}$ grain of chlorine per drop. The greatest care should be exercised in dropping the fluid, since the size of a drop varies so much. It should be dropped from an ounce bottle, and the drop allowed to form slowly.

Prepare a very weak solution of nitrate of silver, by dissolving a crystal, not larger than half a pea, in about one ounce of pure rain-water. There will be hardly any risk of making this solution too weak. Also prepare a solution of chromate of potash: bichromate of potash will answer the purpose if the chromate cannot be obtained. The solution should be made in rain-water. The strength of it is not important.

APPLICATION OF THE TEST.

Pour four ounces of the water to be tested into a saucer, and add enough chromate of potash solution to impart a distinct yellow color; then add a drop of the silver solution; a red color is produced where the the drop strikes, from the formation of chromate of silver, which is quickly destroyed if the water contains much salt; continue to add the solution of silver drop by drop, counting the drops, and stirring the water after each additional drop, until it assumes a faint reddish tint, which will occur as soon as all the chlorine has been precipitated. Then pour four ounces of clean rain-water into another saucer, add one drop of the solution of salt, observing the precaution already given about the size of the drop, and proceed as before. If it takes a larger number of drops of the silver solution to produce a reddish tint in this than were required to produce it in the other case, the water tested contains less than one grain of chlorine per gallon, since $\frac{1}{32}$ grain in four ounces of water is at the rate of one grain in 128 fluid ounces, or one gallon. If more drops of the silver solution were added to the water than to the fluid used for comparison, it is easy, from the number of drops added to the latter, to estimate the chlorine in the former. For example, suppose ten drops of silver solution represent one grain of chlorine per gallon, and the water in question requires thirteen drops: then it contains 1.3 grains of chlorine per gallon. From this it will be seen that if the solution of nitrate of silver is sufficiently weak, it is possible to estimate very small quantities of chlorine, providing the quantity of salt in the fluid used for comparison be known. But on account of the difficulties in the way of weighing, measuring, and dropping, nothing but an approximation can be expected from the process. We think that by careful working the approximation may be made to exceed half a grain.

AMMONIA.

A minute and variable quantity of ammonia exists in the atmosphere. From this source rain-water receives it, which contains less than 0.5 part per million. The earth, in turn, absorbs it from rain-water, while some of it is destroyed by oxidation, so that rivers seldom contain more than 0.1 part per million, and perfectly pure spring or well water contains only a mere trace.

The ammonia process in water analysis is an indirect method of measuring the amount of organic matter which a water contains. Of course all the ammonia, as such, that any natural water might ever contain, is perfectly harmless. The decay of organic matter produces ammonia, and importance is attached to the latter only as it indicates the existence of the former.

In the laboratory two kinds of ammonia are recognized, " free " and " albuminoid." Free ammonia is that which has resulted naturally from the decay of organic matter contained in the water, and, other things being equal, shows how extensively such decomposition is going on. It is easily collected by distillation.

Albuminoid ammonia is that which results from hastening decomposition artificially. It measures the amount of organic matter present which may decay, and is simply what would be produced naturally in the course of time.

The ammonia process, when fully carried out, is the most reliable method known for determining the organic condition of water. To arrive at a correct conclusion in every case, it is necessary to estimate accurately both kinds of ammonia. The determination of albuminoid ammonia requires special apparatus, and is too complicated for general application ; but the test for free ammonia is quite easily made, and from a series of experiments and observations it has been found that, generally, whenever a certain amount of free ammonia occurs in well-water, an excess of albuminoid ammonia is almost sure to exist. So it is pretty safe to conclude that such water is polluted. Says an authority, " When the free ammonia exceeds 0.08 parts per million, it almost invariably proceeds from the fermentation of urea into carbonate of ammonia, and is a sign that the water in question consists of diluted urine in a very recent condition.

In these instances the water will likewise be found to be loaded with chlorides." Our experience places the amount a little higher than 0.08. We believe if a water contains 0.1 part per million of free ammonia, it should be regarded organically impure, especially if other indications point the same way. Of course there are exceptions. Some waters, organically pure, naturally contain much free ammonia, while others, that are badly polluted with vegetable matter, may contain sometimes much less than 0.1 part per million. In such cases the determination of albuminoid ammonia is indispensable to the detection of pollution. It is to be regretted that there is no simple and reliable method for doing this. But the cases are rare where water polluted with vegetable matter contains less than 0.1 part of free ammonia per million.

THE DETECTION OF AMMONIA.

The following process for detecting and estimating free ammonia is sufficiently simple and accurate for general application:

Dissolve some mercuric chloride (corrosive sublimate, a poison) in a little water, making the solution quite strong. Also prepare a strong solution of carbonate of soda (common cooking soda will do) by dissolving it in water. Place a tumbler of clear glass on a black surface in good light; fill it with the water to be tested, and then add a single drop of the solution of mercuric chloride, followed by a drop of the soda solution in the same place. Let the liquid stand without stirring. Look down through it, and if ammonia is present, even a minute quantity, a white cloud or opalescence, resembling white smoke, will be observed towards the bottom of the glass where the drops passed, which in the course of some hours will settle and cover the whole or part of the bottom of the glass with a white coating. If much ammonia is present, the reaction will be very marked, and almost instantaneous. Less ammonia requires more time, and the reaction is less marked.

The delicacy of the test is sufficient to give within five minutes a distinct reaction in water containing $\frac{1}{1,000,000}$ part of its weight of ammonia. Any one can satisfy himself of the delicacy of the test, by the following: Add to a spoonful of water free from ammonia (water that has been boiled for some time) a single drop of ordinary ammonia; then add a drop of this to a tumbler of water that has been well boiled, and apply the test in the manner described above.

If water shows the reaction, it is far from the sanitary standard for purity, which, as has been said, is not more than 0.1 part per million, and this number is ten times less than $\frac{1}{1,000,000}$, the limit of the test. Consequently, a water may contain too much ammonia and not show the reaction. To obviate this difficulty, a simple process of distillation must be employed.

If all the ammonia that ten volumes of water contain could be collected in one volume of water, and the test applied to this and a reaction occur, it is evident that the water in question contains at least 0.1 part per million. To effect the distillation, add two and a half quarts of water to a teakettle, and less if this quantity should come above the spout; then wrap one or two towels around a perfectly clean milk-can, covering the sides and bottom well. The can may be of any size, one that will hold two quarts is convenient. If a can is not to be had, a fruit jar, or a large pitcher, will answer the purpose. Support the can in a nearly horizontal position so the spout of the kettle shall be in the mouth of it. Keep the towels wet by pouring cold water upon them constantly after the water begins to boil. A basin should be placed beneath to catch the water as it runs from the towels. The steam, together with the ammonia, will be condensed in the can. When a half pint, or a tenth, of the water has come over, the operation should be stopped, and the condensed water tested, as described above. If no reaction occurs within five minutes, the water is sufficiently free from ammonia. If a milk-can is used for the condenser, it should be most thoroughly cleaned, otherwise the condensed water will have a milky appearance, which will greatly interfere with seeing the reaction.

NITRATES AND NITRITES.

The presence of these salts is a bad indication only so far as they have resulted from the oxidation of nitrogenous organic matter. Nitrates contain more oxygen than nitrites, and have required more time for their formation. Their occurrence, taken alone, teaches nothing positive; taken in connection with other evidence, it gives valuable information. But as a rule, the presence of more than a trace of either salt is a strong indication of pollution from animal matter. However, some pure waters contain nitrates which they have dissolved from the earth and rocks of the locality. On the other hand, some very bad waters, especially those contaminated with vegetable matter, do not contain a trace.

A little nitric acid exists in the atmosphere, coming probably from the oxidation of ammonia. Hence rain-water contains it, and surface-water receives an additional supply from the oxidation of nitrogenous matter on the ground. It is then absorbed largely by the rootlets of plants. Hence shallow wells may receive it from surface-water. Other things being equal, they would naturally contain more of it when vegetation does not flourish.

The importance that is to be attached to distinguishing whether the nitrogen compound is a nitrate or nitrite, is this generally: If nitrites occur, it would seem to show that the pollution is recent, or its source very near. If nitrates alone exist, it would be inferred that there has been time enough for complete oxidation, and hence the pollution is of longer standing, or its source far away. It sometimes happens that the occurrence of nitrates indicates the approach of pollution instead of showing actual or past pollution. This is especially the case when there is no other evidence of impurity, unless it is that of chlorine, for the soil about a well acts as a filter to retain deleterious matter, letting pass through it only the ultimate products of decomposition, which are in themselves harmless, until it becomes so saturated with filth that it can no longer accomplish this.

NITRATES AND NITRITES DETECTED.

The following method for detecting nitrates and nitrites is delicate and easily applied:

Melt some zinc in a ladle, or iron spoon; stand in a chair and pour the melted metal in a fine stream into a pail of water standing on the floor. This granulates the zinc so it presents the greatest extent of bright surface. Prepare a little thin starch paste in the ordinary manner, dissolve a few grains of iodide of potash in water, and mix it thoroughly with the paste. Have at hand a little sulphuric acid.

To test for nitrites, add half a teaspoonful of the iodide of starch solution to a tumbler of water, and allow to mix. Then add a single drop of sulphuric acid. If any more than a trace of nitrous acid is present, a distinct blue color will result almost immediately. The test is so delicate that it gives, within a few seconds, a distinct reaction in water containing only the one hundred thousandth part of its weight of nitrous acid. And within a few minutes it will reveal less than one millionth part of it. If the color does not appear at the end of a few minutes, it may be decided that no nitrous acid resulting from filth is present. After standing several hours, the liquid usually assumes a blue color from the infinitesimal amount of the acid that may naturally exist in the water.

If no nitrous acid, or but very little, is present, test for nitric acid as follows: Pour a pint of the water into a small nappy, add a spoonful of granulated zinc, and boil until about half of the water it driven off. This process reduces the nitric acid to nitrous acid. Let it cool and settle. Carefully pour off the clear liquid, and test by the method given above. If nitrous acid has been found previously, it will be necessary to notice whether the reaction in this case is more prompt and marked. It is well to have two glasses in readiness at the same time, one containing the water as it came from the well, the other, that which has been boiled with zinc; add a little of the iodide of starch solution, and then a drop of sulphuric acid to each, as nearly at the same time as possible, and notice whether the reaction occurs in one sooner than in the other, as well as whether the color varies in intensity. If much nitrous acid occurs, it will be impossible to detect nitric acid by this process. When this is the case, the detection of nitric acid is not important. If a quite prompt and marked reaction for either nitrous or nitric acid takes place, the quantity is sufficient to render the water suspicious, and their presence forms a very valuable confirmatory indication of pollution in cases where a doubtful quantity of chlorine or ammonia occurs.

Any one desiring to do so, can easily perform interesting and instructive experiments by operating on water in which a little nitrate of potash (saltpetre) has been dissolved.

LEAD AND IRON.

It is of the utmost importance to know whether water used for drinking purposes contains lead. A little gradually taken into the system does not pass off, but accumulates until the quantity is sufficient to result in bad, if not fatal, consequences. Since the poison is so insidious in its action, one does not receive warning until it is too late.

If a piece of bright lead is exposed to moist air, it soon becomes tarnished from the formation of a thin film of protoxide of lead, produced by the action of atmospheric oxygen. If this piece of lead should be now placed in water perfectly pure and free from air, the oxide would dissolve, leaving the metal bright, after which there would be no further action, since no more oxide could form. But if air had access to the water, the twofold action of oxidation and solution would continue together, and the surface of the metal would remain more or less bright, according as the oxide is formed faster or slower than it can dissolve. If some sulphate or carbonate be now added to the water, these salts immediately react with the oxide to form on the metal an insoluble coating of carbonate or sulphate of lead, which, being insoluble in water, prevents further action. These facts explain the behavior of natural waters toward lead. In the first place the protoxide of lead is always formed, which dissolves if the water does not contain the necessary saline constituents to prevent it. Water that contains any salt of lime or magnesia in excess is called hard water. Generally these bases are present in the form of carbonates or sulphates: hence the commonly accepted view that hard water does not act on lead. But here is an error that must be guarded against. The water fails to act on lead, not because it is hard, but because it contains sulphates or carbonates. A soft water, containing sulphates or carbonates of the alkalies, has no action on lead. On the other hand, a water hard from the presence of carbonate of lime or magnesia frequently acts on lead freely, because the same acid that dissolves them and explains their presence, also dissolves carbonate of lead. Hence it is plain that some very hard waters, highly charged with carbonic acid, readily act on lead. The decomposition of organic matter produces carbonic acid; consequently the presence of organic matter facilitates the action of water on lead. Nitrates dissolve lead freely. The metal should not be used in waters containing them. Sulphates in water protect lead most, since the sulphate of lead is insoluble in water and acids. Carbonates are next in order. The carbonate of lead is insoluble in water, but soluble in acids, even the weak carbonate acid.

Water that is hard is so, generally, from the presence of sulphates or carbonates of lime and magnesia, so that ordinarily it might be considered safe to use lead in hard water. But since there are exceptions both against hard water and in favor of soft water, the only safe way is to test every water in which lead is used.

Hard water is readily known from its behavior with soap. In such water considerable soap is required to produce a foam, and quite a quantity of white or gray flakes will appear on the surface of the water. This substance is really lime, or magnesia soap, these bases having taken the place of the soda and the potash which the soap contained. When the hands are washed in hard water, unless enough soap is used to make a good foam, it is impossible to give them a clean feeling. The hardness of water may be an indication that it does not act on lead.

Another rough method is, to observe whether the surface of lead which has been in water for some time is bright and shining, like newly cut metal, or is dull in color, very gray, or brownish. Too much reliance should not be placed upon the color, for the oxide may not dissolve fast enough to keep the metal bright, and yet too much may dissolve. However, if the surface is bright and clean, the evidence is decisive; for it would not be so if the oxide did not dissolve.

THE TEST FOR LEAD.

Prepare a solution of sulphide of soda as follows: Thoroughly mix a small quantity of sulphur (about a teaspoonful) with twice its quantity of cooking soda; put the mixture in an iron spoon, or ladle, and heat it over the coals until it is well melted and the flame of the sulphur has gone out. Scrape the black residue from the spoon, and add to it in a small bottle an ounce of water. Let the solution stand for several hours until the insoluble parts have settled, then pour off the clear, yellowish green liquid into another bottle. Have at hand a little hydrochloric acid (muriatic acid). Fill a tumbler of clear glass with the water to be tested; place it on a white surface in good light; add one drop of the sulphide of soda solution, stir the liquid, and if lead is present it will assume a brownish black color, the depth of color depending on the amount of lead. To ascertain whether the color is due to lead and not to iron (for the sulphide of iron is also black), add to the solution a single drop of hydrochloric acid, and stir it. Do not add the acid until after the sulphide has been added. If the color disappears, it is due to iron; if it grows paler, but does not disappear wholly, it is partly due to iron and partly to lead; and if the color does not change, lead is the cause of it. After the acid is added the liquid is apt to assume a slightly milky appearance from the separation of sulphur. Care must be exercised not to confuse this with an actual fading of the color.

Good water should contain less than one tenth grain of lead per gallon. The test gives a distinct reaction with less than this amount. But the exact quantity connot be determined outside of the laboratory. Unless one is so particular to know the amount as to have the work done, it is best to reject a water that gives any coloration with the test, since it is safer to drink no lead at all.

IRON.

It is not often that a water is found which contains enough iron to be prejudicial to health. Some authorities say that there ought not to be more than two tenths grain per gallon, and others think that water containing one half grain per gallon is not injurious.

Iron is detected by means of sulphide of soda and hydrochloric acid. If no lead is present, the color produced by the sulphide must dissolve completely on the addition of two or three drops of acid.

If it be desirable to learn whether there is more than half a grain of iron in a gallon of any water, dissolve one ounce avoirdupois of sulphate of iron (copperas) in eleven ounces of water.

Each drop of this solution contains about one sixty-fourth grain of iron. Add one drop of the solution to four ounces of pure water, which will then contain iron at the rate of about one half grain per gallon. Add to this a drop of sulphide of soda, and compare the color with that of the water in question.

THE PERMANGANATE OF POTASH.—TEST FOR ORGANIC MATTER.

The union of oxygen with dead organic matter always occurs when the two are brought together under favorable circumstances, and the disappearance of the one may be made to reveal the presence of the other.

The solution of permanganate of potash has an intensely deep purple color, which is owing to the oxygen it contains. Whenever this solution is brought in contact with easily oxidizable substances, it loses its oxygen and consequently its color. If, therefore, enough of the solution be added to a suspected water to impart a distinct tint, and the color disappears, it is certain that something is present which is capable of taking the oxygen from the permanganate. Whether this is organic matter, or something else, is uncertain without the application of other tests. The only other substances which are apt to occur in a water, and are capable of effecting the change, are ferrous salts, nitrites, and hydrogen sulphide. If these are known to be absent, and the color of the permanganate disappears, it may be decided that organic matter is present. But if either of these occurs, the test has no value.

The methods for detecting nitrites and iron, which is most always, when present, in the form of a ferrous salt, have been given. Sometimes, however, iron occurs in water as a ferric salt. This does not affect the permanganate; but the method given for detecting iron makes no distinction between its two classes of salts. To distinguish them is too difficult, except for the chemist.

To detect hydrogen sulphide, shake some of the water in a clean bottle, and observe the odor, which is the same as that emitted by the solution of sulphide of soda.

It is another drawback to the permanganate test that it does not act on albuminous substances, urea, kreatin, sugar, gelatine, or fatty matters. So that a water might be very badly polluted and yet give no indication of it with this test. Cases are recorded where sickness resulted from the use of water supposed to be good, because it did not affect the permanganate. Other instances are recorded where good water was condemned from the application of this test. From what has been said, it will be seen that this test alone is reliable only when iron, nitrites, and hydrogen sulphide are known to be absent, and at the same time the color of the solution disappears. It is often valuable as a confirmatory test, and for that purpose it is described here.

The solution is easily prepared by dissolving the crystals of permanganate of potash in pure water. To apply the test, take two tumblers of clear glass : fill one with water of known purity, and the other, with the water to be tested : then add a drop of the solution to each, and compare the change in color. Those who have been accustomed to work by this method are guided by the following rules : "If decomposing organic matter be present in a degree hurtful to health, the pink color is changed to dull yellow ; or, if a still larger quantity exists in the water, the color will in time entirely disappear. Where the color is rendered paler, but still retains a decided reddish tinge, then, although putrefying organic matter is present, it is so in such minute quantities as are not likely to be immediately hurtful. The quicker and more perfect the decoloration of the water tested, the greater is the quantity of decomposing organic matter.

The following preparation of permanganate is a more delicate and perhaps a more reliable test than the simple solution :

Caustic potash, . . .	4 parts by weight,
Permanganate of potash, . .	1 part "
Distilled water, . . .	160 parts "

If it is found inconvenient to weigh the very deliquescent caustic potash, the liquor potassæ of commerce may be substituted. Then the formula is :

Liq. potassæ, ...	70 parts,
Distilled water, ...	90 "
Permanganate of potash, . . .	1 part.

If the solution is kept in a glass-stoppered bottle in a dark place, it will remain good for a year or more. This test is applied in the same manner as the simple solution. It is claimed that water of average good quality, with this test, will keep its color well for forty-eight hours. If it becomes decidedly paler in twenty-four hours, it is hardly fit to use. Those who employ the method do not claim for it scientific accuracy, but think, in the absence of opportunity for a more careful analysis, a ready and reliable conclusion may be reached. We think the claim for reliability is too strong on account of the same reasons that were given under the description of the simple solution.

It would be interesting and profitable for any one purposing to use the permanganate test in either form, to collect samples of water from several sources,—wells, springs, brooks, and stagnant pools,—and to apply the test to them, comparing the results. It would be well to do the following also: Add a little sulphate of iron to water distinctly colored with permanganate. The color will quickly disappear. Repeat the experiment, using nitrite of potash, having prepared some by boiling a solution of saltpetre with zinc. The effect of hydrogen sulphide may be seen by doing the experiment with sulphide of soda.

INTERPRETATION OF RESULTS.

Nearly enough has been said under the several divisions to direct one to fair conclusions. It must not be inferred that the methods presented here are infallible guides to the quality of a water. All that can be claimed for them is, that in most cases they will reveal the character of waters which are so polluted as to be immediately injurious to health. Some, that are polluted with vegetable matter alone, may escape detection. Other tests, which cannot be used by people generally, must be made before all that can be known of a water will be revealed.

It is seldom that a bad water will show all the indications that have been described. If an excess of both chlorine and ammonia occurs, the water is polluted with animal matter or with drains. If considerable chlorine is present together with a strong reaction for nitrates or nitrites, while ammonia is not found by means of the test described, a past or future pollution is indicated. If an excess of ammonia alone occurs, contamination from vegetable matter is suggested, which becomes quite certain if the sugar test and the permanganate of potash have given a reaction.

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