The Chemical Analysis of Potable Waters

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THE CHEMICAL ANALYSIS OF POTABLE WATERS.

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THE CHEMICAL ANALYSIS OF POTABLE WATERS.

Water is necessary in all forms of vegetable and animal life, even in the lowest types. Man has always used water in many ways. He has used it as his carrier, transporting his goods for him from one place to another; he has used it to turn his mill wheels and generate his electricity. He has forced it to be his scavenger allowing it to carry his refuse out of his sight. The greatest of its uses to the human race is as a refreshing draught. Man has seldom thought of the effect on his neighbor of this treatment of their common property and laws have been enacted restricting his actions. In common law, water is held to be a gift of nature to man to be used by all and must therefore not be diverted from its natural channels for the pleasure or profit of any one to the exclusion of the rest.

The ideal water should be above suspicion, for if it once has been contaminated, it is not easy to tell how soon or how likely it will occur again. Although "pure" water is only found in the laboratory, a "safe" water, that which is reasonably free from objectionable substances, mineral and organic, may be obtained with sufficient care and knowledge.

The examination of a water to determine its safety for domestic use is called a sanitary analysis, in distinction from that examination which determines its fitness for manufacturing purposes, for use in steam boilers, or its medicinal value. In this analysis there are four points to be determined: First, the amount, if any, of organic matter in a living or a dead condition, suspended or dissolved in the water; second, the amount and the character of the products of the de-
composition of the organic matter and their relative proportions to one another; third, the stability of the undecomposed organic substances; fourth, the amount of certain mineral substances dissolved.

Formerly man, when he was thirsty, drank from the sparkling springs and brooks, but today in the crowded condition of the country one has to search farther and farther for a supply of good water. It is not enough that the water should be free today from disease germs, but it should remain free from changes for a reasonable length of time. To be fully "acceptable," a water should be free from color, odor, turbidity and sediment, and should be of a uniformly low temperature to permit its use without ice. "Safe" water is one that carries neither seeds of disease nor such substances as are deleterious to the health of mankind in general.
COLLECTION OF SAMPLES.

For the collection of water samples, glass-stoppered bottles of about a gallon capacity are best. Pottery jugs or metal containers are not to be used. The bottles must be thoroughly washed before the sample is poured into them. This is best accomplished by washing them with a solution of dilute sulphuric acid and potassium bichromate and by thoroughly rinsing with distilled water and draining.

Samples from a water tap. The water was allowed to run freely from the tap for a few minutes before the sample was collected. The bottle was placed under the tap and rinsed out with the water three times, the water being poured out completely each time. It was then placed under the tap and filled to overflowing. A small quantity was poured out so as to leave an air space of about an inch. The stopper was rinsed off with the water from the tap and put into the bottle while still wet. A piece of clean cotton cloth was tied over the stopper to exclude dust and dirt. Care was taken that the hands did not come in contact with the inside of the neck of the bottle or the stem of the stopper.

Samples from a stream, pond or reservoir. The bottle and stopper were rinsed with the water, care being taken that the sediment was not stirred up. The stopper was put in place and the bottle sunk beneath the surface and the stopper removed. The stopper was replaced beneath the surface when the bottle was full. It is very important in this connection that the sample be collected free from scum on the surface of a stream and from sediment on the bottom.
DETERMINATION OF THE TURBIDITY AND SEDIMENT.

The suspended matter remaining in the water after it has rested in the collecting bottle for twelve hours, or more, is called its turbidity, and that which has settled to the bottom of the bottle, its sediment.

Good ground waters are often free from any turbidity and sediment, the suspended matters having been filtered out through its subterranean passage, but this is rarely true of surface waters. The turbidity is various in character and amount, sometimes milky from clay or ferrous iron in solution; usually it consists of fine particles, generally living algae or infusoria. These often collect on the side toward the light while some collect on the opposite side, and a practised eye can, not infrequently recognize their forms. Some of the lower animal forms can be seen with the naked eye, and the larger Entomostraca are quite noticeable in many waters.

The sediment may be earthy or flocculent; in the latter case it is generally debris of organic matter of various kinds. The degree of turbidity is expressed by the terms "very slight," "slight," "distinct," and "decided," and the degree of sediment by "very slight," "slight," "considerable," and "heavy."
DETERMINATION OF THE ODOR.

Cold. A large collection bottle about half full of the water was shaken violently, the stopper removed and the odor noted. The odor can often be detected in this manner when it would not be noticed if poured into a tumbler.

Hot. A large beaker was about one third filled with water. It was covered with a watch-glass and placed on an iron plate which had been previously heated so that it would come quickly to a boil. When the air bubbles had all been driven off and the water was just about to boil, the beaker was taken from the plate and allowed to cool for a few moments. It was then shaken with a rotary motion and the watch-glass slipped aside and the odor noted. In this case the odor may or may not be the same as when the water was cold.

These determinations of the odors of the water when hot and cold are very important, as the odors are usually connected with some organic growths or with sewage contamination, or both. The odor of ground waters is often caused by the earthy constituents of the water-bearing strata.

Certain organisms can be distinguished by their odors, as, for example, the "fishy" odor of Uroglena; the "aromatic" or "rose geranium" odor of Asterinoella and the "pig-pen" odor of Anabaena.

The qualities of the odors are as follows:

- vegetable
- fishy
- musty
- aromatic
- earthy
- disagreeable
- grassy
- moldy
- peaty
- sweetish

The intensity of the odor may be expressed as follows:

None. No odor perceptible.
Very faint. An odor that would not be detected by the average person, but that could be detected in the laboratory by the experienced observer.

Faint. An odor that the consumer might detect if his attention were called to it, but would not attract attention otherwise.

Distinct. An odor that would be detected readily and might cause the water to be looked upon with disfavor.

Decided. An odor that would force itself upon the attention and that might make the water unpalatable.

Very strong. An odor of such an intensity that the water would be absolutely unfit to drink. This term is only used in extreme cases.

The very close relation existing between the odors of the waters and the living flora and fauna makes it desirable that the chemist shall be able to recognize the more common forms of water plants and organisms. Therefore a microscope and concentration apparatus should be in every water-laboratory.
Nitrogen is the essential element in all living matter, from the lowest organisms to the very highest. All organisms thrive only in the presence of food and so organic matter which serves to support life or which as a "product of life" may be deleterious to the health of man is rightly held to be dangerous. The element which is the common constituent of both kinds is nitrogen, and therefore in analytical work it is necessary to seek evidence of its presence or absence and also of the forms in which it occurs and their relation to each other.

A nitrogenous compound is dangerous from two causes. First, it is already decaying and harbors pathogenic germs giving off toxins, and second, it furnishes food for the further development of bacteria. The first products of decay of these organic nitrogenous materials are carbon dioxide and ammonia. It is to the latter that we turn for our proofs in the matter of water pollution. The presence of ammonia in water is not a sufficient proof that it has been recently polluted by human sources. Rain water contains it in considerable quantities and decaying blue-green algae furnish it in large amounts. However, it is held to be one of the chief witnesses in the case for ammonia is found in sewage in a thousand times the quantity in which it occurs in potable water.

While putrefaction takes place by stages, the lines of division are not sharply drawn and nitrites, the result of the second stage, may be and usually are found in contaminated water together with ammonia. The nitrates, which are in the next stage, are no longer classed as organic.
DETERMINATION OF FREE AND ALBUMINCID AMMONIA.

The apparatus for the determination of ammonia is shown on the following page. It consists of a round bottom flask of about 900 c.c. capacity, with square shoulders and a narrow neck about five inches long, and an ordinary Leibig condenser fitted with an inner tube of block tin, about a quarter of an inch in diameter. The flask is closed by a cork which is fitted with a tube which passes into the condenser for some distance. The flask is heated with the free flame of the Bunsen burner.

The flasks were cleaned with a boiling solution of dilute sulphuric acid and potassium bichromate before being used and the corks were steam ed an hour. The distillates were received directly in the Nessler tubes. These tubes are about eleven inches long and of five eighths of an inch internal diameter, with the 50 c.c. mark at least two inches from the top.

METHOD. The apparatus was freed from ammonia by distilling the water in the flask and testing each 50 c.c. of the distillate with Nessler's Reagent until no color was given. The remaining water was poured into a bottle marked "Ammonia Free Residues." The sample of the water to be examined was shaken well to mix the contents and 500 c.c. were taken. This was poured into the distilling flask and three portions of 50 c.c. were distilled. If the amount of ammonia in the water is very high a lesser portion than 500 c.c. should be taken and diluted to 500 c.c. with water free from ammonia.

After the free ammonia distilled off, the contents of the flask were allowed to cool and 40 c.c. of alkaline permanganate were added through a funnel tube, care being taken that none of the solution touched the neck of the flask. The contents were again subjected to distil-
In this case the albuminoid ammonia was collected in the distillate having passed over with the steam. Five portions were taken in this determination. In order to obtain about one half the total organic nitrogen, the flame was regulated so that the time for distilling 50 c.c. was not less than five minutes nor more than eight.

**STANDARD AMMONIUM CHLORIDE SOLUTION.** 3.82 grams of C.P. ammonium chloride were dissolved in a liter of ammonia free water. This is the stock solution from which the standard solution is made. 10 c.c. of this solution were diluted to a liter with water free from ammonia.

One c.c. of the standard solution equals 0.00001 gram of Nitrogen.

**NESSLER'S REAGENT.** 61.760 grams of potassium iodide were dissolved in 250 c.c. of distilled water and a cold solution of mercuric chloride was added until a slight permanent red precipitate (mercuric iodide) appeared. The mercuric chloride solution was saturated by boiling an excess of the salt in water and allowing it to cool when it crystallized out. The red precipitate was redissolved by adding to the solution 0.750 gram of powdered potassium iodide, 150 grams of potassium hydroxide dissolved in 250 c.c. of water were added and the whole made up to a liter and allowed to settle. This solution gives the required color with ammonia within ten minutes and does not precipitate within two hours.

**ALKALINE PERManganate.** 288 grams of the best stick potash were dissolved in water and filtered through glass wool. It was diluted with distilled water to a specific gravity of 1.125 and 8 grams of potassium permanganate crystals were added. It was then boiled down to one liter to free it from nitrogen.

Standards were prepared by adding to Nessler tubes nearly filled with ammonia free water varying quantities of the standard ammonium
chloride solution. The contents were well mixed by rotating between the palms of the hands and allowing them to stand for several minutes. Two c.c. of Nessler's Reagent were added to each of the standard tubes and to the samples as rapidly as possible. The colors were matched at the end of ten minutes by looking vertically downward through the tubes at a piece of white paper placed in front of a window at an angle in such a way as to reflect the light. A depth of color given by about 6 c.c. of the standard solution is about the limit of satisfactory comparison.

The compounds produced by the action of ammonia on Nessler's Reagent are considered as the substitution of one Hg for two H in ammonia. They are called mercur-ammoniums. Tetra-mercur-ammonium iodide is a brown-yellow precipitate which is soluble in an excess of potassium iodide in the presence of potassium hydroxide with a brown-yellow color, proportional within certain limits to the amount of ammonia.

The "free ammonia" does not exist in the water in the free state nor as the hydroxide, but is probably present as the chloride or the carbonate. When the water containing these compounds is boiled they are decomposed and the free ammonia passes off with the steam and is found in the distillate.

After the readings were made and recorded, the results obtained by nesslerizing each portion of the distillate from each sample were added together. This sum multiplied by .02 (if 500 c.c. of the sample were tested) gives the number of parts per million of nitrogen as free ammonia in the sample.
TOTAL ORGANIC NITROGEN BY THE KJELDAHL METHOD.

A portion of the sample (500 c.c.) was boiled in a round bottomed flask until freed from ammonia. This required the loss of about 200 c.c. These first distillates were tested for ammonia by the method given above. When the ammonia has all been distilled off 5 c.c. of C.P. concentrated sulphuric acid free from nitrogen and a piece of ignited pumice were added. The solution was mixed by shaking and then placed over a flame in the hood. It was boiled cautiously until all the water was driven off and fumes of sulphuric acid were given off and the liquid charred and finally became colorless. It was removed from the flame and potassium permanganate crystals were added until a heavy green precipitate persisted in the liquid. It was cooled and then diluted with 100 c.c. of ammonia free water. It was neutralized with ammonia free sodium carbonate solution (ten percent) and then distilled. The distillates were collected in the Nessler tubes and the colors matched as given above.

Another modification of the process is as follows. After the acid became white it was allowed to cool and the neck of the flask was rinsed down with ammonia free water. It was attached to the condenser and 100 c.c. of potassium hydroxide were added through the separatory funnel. The ammonia was then distilled by steam. The distillation was conducted slowly until the first 50 c.c. had been collected and then more rapidly until 175 c.c. had passed over. The distillate was diluted with 250 c.c. of distilled water and 50 c.c. were taken for nesslerization.

POTASSIUM HYDROXIDE. 350 grams of the best stick potash were dissolved in 2.25 liters of water and boiled down to something less than a liter with 3 grams of potassium permanganate crystals. It was cooled and diluted to a liter with water free from ammonia.
DETERMINATION OF NITROGEN IN THE FORM OF NITRITES.

A portion of the sample was measured into a 100 c.c. tube. To this 10 c.c. of sulphanilic acid in acetic acid and 10 c.c. of naphthylamine acetate were added. After standing about ten minutes, not longer, for the color changes on standing, it was compared with standards prepared in Nessler tubes with the standard nitrite solution. When 100 c.c. of the sample are used, then 0.001 when multiplied by the number of c.c. of the standard used gives the parts per million of nitrogen as nitrite. The determination must be completed within a half hour as the air of a room in which gas is burning contains nitrites.

STANDARD NITRITE SOLUTION. 1.1 gram of pure silver nitrite were dissolved in nitrite free water and the silver precipitated by sodium chloride. This solution was diluted to a liter. 100 c.c. of this stock solution were diluted to a liter with sterilized water and 1 c.c. of chloroform added. One c.c. of the standard solution equals 0.0000001 gram of Nitrogen.

SULPHANILIC ACID. 3.3 grams of sulphanilic acid were dissolved in 750 c.c. of water by the aid of heat and 250 c.c. of glacial acetic acid were added.

NAPHTHYLAMINE ACETATE. 0.5 gram of a-naphthylamine was boiled in 100 c.c. of water in a small Erlenmeyer flask for five minutes. It was filtered through a plug of washed absorbent cotton. 250 c.c. of glacial acetic acid were added and the whole diluted to a liter.
DETERMINATION OF NITROGEN IN THE FORM OF NITRATES.

2 c.c. of the water from the sample bottle were taken in this determination. The water was transferred to a porcelain evaporating dish with a capillary pipette. The dish was placed on the water bath and the water allowed to evaporate until only a few drops were left. These were left to evaporate spontaneously in a place free from dust. When entirely evaporated six drops of phenol disulphonic acid were added and brought in contact with the residue by rubbing around with a glass rod. The acid was then diluted with 7 c.c. of distilled water and 3 c.c. of potassium hydroxide (1:3) added.

Standards were prepared by measuring varying amounts of standard nitrate solution, up to 8 c.c. into Messler tubes. Chlorides interfere with the delicacy of this test, but not to any extent if the amount is less than twenty parts per million. Nitrites do not interfere with the test.

STANDARD NITRATE SOLUTION. 0.720 gram of pure potassium nitrate was dissolved in a liter of water. 10 c.c. of this strong solution were evaporated on the water bath and then moistened quickly and thoroughly with phenol-disulphonic acid and diluted to a liter for the standard solution. One c.c. of the standard solution equals 0.000001 gram of nitrogen.

PHENOL-DISULPHONIC ACID. 3 grams of synthetic phenol and 37 grams of 0.P. concentrated sulphuric acid were heated together on a boiling water bath for six hours.
DETERMINATION OF CHLORINE IN WATER.

The chlorine of unpolluted waters comes from the sea either in the past or the present. When the waves break upon the rocky shores they send the finely divided salt spray high into the air. Dust particles become coated with it and are carried by the wind inland. The rain water carries it to earth and thus the amount of this salty dust in each region is proportional to the amount of rainfall and the distance from the coast. No mountain lake or stream has yet been found which is free from this element. Salt springs and salt wells may also be a source of supply. Streams may contain much salt from manufacturing establishments situated along their banks, but the excess of chlorine, above normal, in the absence of salt springs, is due to the domestic life of man. Chlorine may serve to prove not only the presence, but the amount of sewage pollution in any case where the other factors are known.

In order that any data which might be obtained relative to the amount of chlorine present in the water might be useful the normal chlorine content of the waters in the vicinity must be known. Maps are prepared showing these isochlors and normal chlorine content of the water can be reckoned. The sources of the excess of chlorine over the normal are usually the sink-drain with the salty water from the household; the house drain with its chlorine containing excreta; and the stable drain with a slight content as compared with the others.

The chlorine is determined in natural waters by titrating with a solution of silver nitrate, using potassium chromate as an indicator. The silver nitrate solution must be standardized by each person for himself because the color change which constitutes the end point is very sensitive and varies with the eyes of different observers. 25 c.c. of
distilled water were measured into a porcelain evaporating dish and 5 c.c. of sodium chloride solution were added from a burette together with three drops of potassium chromate solution. It was then titrated with silver nitrate solution until a reddish brown color appeared.

Waters which contain twenty or more parts per million are titrated directly, using about 25 c.c. Waters which are low in chlorine are concentrated before titrating, 250 c.c. being evaporated down to 25 c.c. For this titration the water must be nearly neutral as possible. If the water is alkaline it should be neutralized with dilute sulphuric acid, using phenolphthalein as an indicator. Acid water must be made neutral with sodium carbonate.

SALT SOLUTION. 16.48 grams of fused sodium chloride are dissolved in a liter of distilled water. For the standard solution this was diluted 100 c.c. to one liter. One c.c. of the standard solution equals 0.001 gram Chlorine.

SILVER NITRATE. About 2.42 grams of silver nitrate (dry crystals) are dissolved in a liter of chlorine free water. One c.c. of this solution equals 0.0005 gram of chlorine approximately. This was standard—against the salt solution.

POTASSIUM CHROMATE. 50 grams of neutral potassium chromate were dissolved in a little distilled water. Enough silver nitrate was added to produce a slight red precipitate. The solution was filtered and the filtrate diluted to a liter with water free from chlorine.
DETERMINATION OF THE HARDNESS.


A clear glass-stoppered bottle was used in this determination. Its capacity was 250 c.c. 50 c.c. of the sample were measured into it and soap solution was added from the burette, a few tenths of a c.c. at a time. The water was well shaken after each addition until a lather formed which covered the entire surface of the liquid for a period of five minutes. The bottle is laid on its side after each shaking. When the water is agitated in the bottle there is a peculiar tinkle which ceases when the proper end point is reached. Tables are used in computing the number of parts of calcium carbonate from the volume of soap solution used. This method gives only the total hardness.

The permanent hardness was determined in this manner. 50 c.c. of the water were diluted to 500 c.c. and boiled down to 50 c.c. The hardness was determined as above. This was the permanent hardness. The difference between the total hardness and the permanent hardness is the temporary hardness.

Special care must be taken in the presence of magnesium compounds and the necessity of adding the soap in small quantities is apparent. The presence of magnesium salts is recognized by the peculiar curdy appearance of the precipitate formed and the occurrence of a false end-point the lather only lasting about three minutes.

By the temporary hardness of a water is meant the hardness that can be removed by boiling. It is due to the carbonates of calcium and magnesium held in solution by the carbonic acid gas in the water, probably in the form of the bicarbonates. Permanent hardness is that which is not removed by boiling and is due to the chlorides and sulphates of calcium.
and magnesium, held in solution by the water itself.


A bottle is used in this determination which is similar to the one used in the soap test. 100 c.c. of the sample were measured into the bottle and 2.5 c.c. of erythrosine indicator were added. The solution is well mixed by shaking and is then titrated with N/50 sulphuric acid shaking well after each addition. The pink color grew lighter until one drop of the acid caused it to disappear entirely. Each tenth of a c.c. of the acid used represents one part of calcium carbonate in 1,000,000. A correction was made for the indicator by carrying out the titration with distilled water.

STANDARD CALCIUM CHLORIDE SOLUTION. 0.200 gram of pure Iceland spar was dissolved in dilute HCl, care being taken to avoid loss by spattering. It was evaporated to dryness several times on the water bath to remove excess of the acid. The calcium chloride thus formed was dissolved in a liter of water.

STANDARD SOAP SOLUTION. 100 grams of the best white, dry Castile soap were dissolved in a liter of 80 per cent alcohol. 75-100 c.c. of this strong solution were dissolved in a liter of 70 per cent alcohol. This solution was standardized against the standard calcium chloride solution and 70 per cent alcohol added to it until it gave the required lather with 50 c.c. of the standard solution, 14.25 c.c. of the soap solution being used.
DETERMINATION OF FREE CARBONIC ACID.

Reagent. Standard N/22 solution of Sodium Carbonate. 2.41 grams of dry sodium carbonate were dissolved in a liter of distilled water which was previously freed from carbonic acid by the cautious addition of a dilute solution of sodium carbonate. 5 c.c. of phenolphthalein were added to the distilled water before neutralizing and measuring. One c.c. of this solution equals 0.001 gram of carbon dioxide.

Method. 100 c.c. of the sample were taken and poured into a narrow tube. It was titrated rapidly with the N/22 carbonate solution, stirring gently until a faint but permanent pink color is produced.

The number of c.c. of the sodium carbonate solution used in titrating 100 c.c. of water, multiplied by 10, gives the parts per million of free carbonic acid.
DETERMINATION OF THE CARBONACEOUS MATTER.

Kubel's Hot Acid Method.

Reagents. Ammonium oxalate 0.888 gram was dissolved in a liter of distilled water. One c.c. is equal to 0.0001 gram of oxygen.

0.4 gram of potassium permanganate was dissolved in a liter of distilled water and standardized against the oxalate solution. One c.c. is equivalent to 0.0001 gram available oxygen.

Method. 100 c.c. of the water were measured into a 250 c.c. flat bottomed flask and 10 c.c. of sulphuric acid and 10 c.c. of potassium permanganate were added. The flask was placed on the wire gauze and heated quickly to boiling. It was boiled two minutes and then removed from the flame and allowed to cool one minute. 10 c.c. of ammonium oxalate were added. It was then titrated with potassium permanganate to a faint permanent pink color. Each c.c. of the exact permanganate used in excess of the oxalate solution used represents 0.0001 gram of oxygen consumed by the sample.

The oxygen given up by the permanganate combines with the carbon of the organic matter and perhaps to a certain extent with the hydrogen, but not with the nitrogen. Thus the amount of oxygen consumed bears some relation to the amount of organic carbon present in the water, but this result cannot be taken as a definite one in every case as the results vary even with the time of boiling.
DETERMINATION OF IRON.

Iron is found in water in the dissolved and suspended forms and in both the ferrous and ferric conditions, depending upon the nature of the sample. The iron is usually in an unoxidized and soluble condition in ground waters. It is sometimes accompanied by carbonic or sulphuric acid, and also in combination with organic matter.

Method. 200 c.c. of the water was evaporated to dryness in an evaporating dish. 5 c.c. of hydrochloric acid was added to the residue, care being taken that the entire residue was brought into solution. The solution was then rinsed into a Nessler tube and made up to 50 c.c. with distilled water. Potassium permanganate is added drop by drop until the solution remains pink for ten minutes. A blank standard is prepared with distilled water and 5 c.c. of hydrochloric acid. 15 c.c. of potassium sulphocyanide solution are added to the water and to the blank standard. Standard iron solution was added to the blank standard in small quantities until the colors matched each other. The colors must be matched immediately after adding the sulphocyanide, since the color fades on standing. One c.c. of the iron solution equals 0.0001 gram of Iron. The highest standard should not contain more than three c.c. of the iron solution since the color becomes too deep for comparison.

Standard Iron Solution. 0.36 gram of ferric ammonium alum was dissolved in 500 c.c. of water and 5 c.c. of nitric acid were added (1.20) and the whole made up to a liter. One c.c. of the standard solution equals 0.0001 gram of Iron.

Potassium Sulphocyanide. 5 grams of the salt were dissolved in a liter of water.

Potassium Permanganate. 5 grams of potassium permanganate crystals
were dissolved in a liter of water.
DETERMINATION OF THE RESIDUE ON EVAPORATION AND THE LOSS ON IGNITION.

A platinum dish was ignited and dried in a dessicator and weighed. 100 c.c. of the water were measured into it and evaporated to dryness on the boiling water bath. When the water was evaporated the dish was placed in an oven and heated for two hours at 100°. It is then placed in a dessicator and allowed to remain for several hours and then weighed. The increase in weight gives the "total solids" or "residue on evaporation."

In order to determine the loss on ignition, the dish was heated in another platinum dish which is larger than the dish containing the residue. This dish is supported in the other by a triangle of platinum wire and an air space is left around it. A disk of platinum foil is suspended above it to radiate back the heat. The larger dish is heated to redness by a Bunsen burner until the residue in the smaller dish is white or nearly so. The odor and the character of the contents were noted. After the dish had cooled the contents were moistened with a few drops of distilled water. The dish was again heated, cooled in a dessicator and again weighed. This gives the weight of the "fixed solids," the difference being the "loss on ignition."

The behavior on ignition is oftentimes significant. Swampy or peaty waters give a brownish residue on evaporation to dryness, which blackens or chars, and this black substance burns off quite slowly. The odor of the charring is like that of wood or grain; sometimes sweetish, but not at all offensive. Waters much polluted by sewage blacken slightly; the black particles burn off quickly and the odor is disagreeable.
Ammonia Determinations.

<table>
<thead>
<tr>
<th>Free Ammonia</th>
<th>Albuminoid Ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st 50 c.c., 0.000</td>
<td>1st 50 c.c., 0.10</td>
</tr>
<tr>
<td>2nd 50 c.c., 0.000</td>
<td>2nd 50 c.c., 0.05</td>
</tr>
<tr>
<td>3rd 50 c.c., 0.000</td>
<td>3rd 50 c.c., 0.00</td>
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<tr>
<td>4th 50 c.c., 0.000</td>
<td>4th 50 c.c., 0.00</td>
</tr>
<tr>
<td>5th 50 c.c., 0.000</td>
<td>5th 50 c.c., 0.00</td>
</tr>
<tr>
<td>0.000 c.c.</td>
<td>0.15 c.c.</td>
</tr>
</tbody>
</table>

In this case free ammonia would be 0.000 and the albuminoid ammonia 0.003 parts per million.

Two drops of egg-white were added to a liter of water and the amount of ammonia determined. There was no free ammonia present.

Albuminoid Ammonia.

| 1st 50 c.c., 2.50 | 1st 50 c.c., 2.50 |
| 2nd 50 c.c., 2.00 | 2nd 50 c.c., 2.00 |
| 3rd 50 c.c., 1.30 | 3rd 50 c.c., 1.30 |
| 4th 50 c.c., 1.00 | 4th 50 c.c., 1.00 |
| 5th 50 c.c., 0.20 | 5th 50 c.c., 0.20 |
| 7.50 c.c. | 7.50 c.c. |

In this case the albuminoid ammonia would be 0.150 parts per million.

Nitrite Determinations.

Nitrite solutions of unknown strength were taken and the amount of nitrite determined. Three solutions were tested.

| 1st solution contained 0.008 parts per million. |
| 2nd solution contained 0.010 parts per million. |
| 3rd solution contained 0.100 parts per million. |

Nitrate solutions of unknown strength were taken and the amount of nitrate determined. Three solutions were tested.
1st solution contained .070 parts per million.
2nd solution contained .250 parts per million.
3rd solution contained .140 parts per million.

Chlorine Determinations.

The chlorine content was 775 parts per million.

Hardness Determination. Soap Method.

This method showed 48.6 parts of calcium carbonate in a million.

Determination of Free Carbonic Acid.

This determination showed .006 parts per million of carbon dioxide.

Determination of carbonaceous matter or "oxygen consumed."

This method showed .00103 grams of oxygen consumed by the sample.

Determination of Iron

This determination showed .08 parts per million.