Sanitary Examination of Waters of Champaign.

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Waters which have been in contact for some time
with decaying organic matter may as a result of such
contact become the bearers of bacteria, producing in those
habitually using such waters diarrheal or malarial di-
sases. Hence the examination of water used for domestic
purposes has become an important feature of sanitary work.
The health departments of different states are every
year doing valuable service and making noted progress
in the examination of water supplies, but as the study
of waters and the effects which any excess of the dif-
ferent impurities they may contain have on the human
body, can be carried on only at considerable cost of time
and money, this branch of science like many others will
only become perfect with time. Massachusetts is the
only state of which it can be truthfully said that
the study of the waters from the different localities has
received the proper attention. There are two general methods of sanitary analysis, the biological which is a search for the already existing bacteria producing disease, and the chemical which seeks to find the presence quantitatively and to some extent the nature of the organic material in which the disease germs thrive. Only the chemical method has been considered in my work.

The polluting substances in water are in the main organic and they may come from many sources, the principal one being contamination from sewage and from the decomposition of animal and vegetable matter.

Inorganic salts which are estimated as as whole come from the salts of the soil and from the oxidation of nitrogenuous substances which is continually going on where there is access of oxygen. Most people except those in large cities get their supply of water from wells and this they will continue to do.
for an indefinite time, these wells range from 20-60 feet in depth and for convenience are usually placed near the house and unless properly protected by brick and cement around the surface. They serve as an outlet into which the water from the surrounding soil finally flows.

Soils possess the valuable property of extracting from waters passing through them organic matter, this quality differs greatly with the nature of the soil; the greatest quantity of organic matter being absorbed or oxidized by passing through a medium fine clay or loamy soil, while very fine or excessively coarse soils are the least efficient in this respect, because the former does not allow the water to pass through sufficiently fast to be available while the latter allows the water to pass through at such a rate that the impurities do not have time to be oxidized. But no matter what the quality of the soil.
If within a few yards of the well, there is a cesspool for domestic wastes, a barnyard and other outbuildings, as is often the case, the soil in this vicinity cannot help but become laden with organic contamination, and then it not only fails to extract or alter the impurities of a water passing through it, but adds to the quantity of pollution. 

From a sanitary standpoint our interest centers itself mainly in the organic matter. This we find first as living organisms; and the products of organic life such as albumen, urea, tissue and etc., which may be dissolved or suspended; and 2nd salts of ammonia and of the acids or mineral matters which serve in turn as food for vegetable life in water. The Carbon and Nitrogen of these compounds is constantly changing from organic to mineral matter, the former being reduced to carbonic acid and the latter into nitrates.
The water here analyzed were collected after a considerable amount of water had been pumped from the well in clean glass-stoppered bottles and where it was possible I made the determinations on the day the sample was collected, at least the Nitrogen. The following determinations were made in each water. Nitrogen as salinic ammonia, albumenoid ammonia, nitrate, nitrite, oxygen consumed, chlorine, hardness and the total solid matter. The methods used were those that have given the best satisfaction and can be performed with the least time and trouble. There are numerous methods for some of these determinations but taking all things into consideration those methods which will briefly describe have been most generally adopted by water analysts.

Preparation of Reagents used in the following Determinations:

For “free” and “albumenoid” Ammonia: Nessler’s Reagent. Dissolve 35 grams polaronium nitrate
and 13 grams of corrosive sublimate in 800 cc of water, heated to boiling, they added a cold saturated solution of corrosive sublimate in water cautiously until the red peroxide of mercury which forms begins to be permanent. It is then rendered sufficiently alkaline by adding 160 grams of caustic potash to the liquid which is afterwards diluted with water up to one litre. In order to make the Nessler reagent sensitive it is mixed finally with a little more cold saturated solution of corrosive sublimate and allowed to settle and decanted off.

Dilute Standard Solution of Ammonia

Dissolved 6.15 grams of pure dry ammonium chloride in 1 litre of water free from ammonia, took a portion of this solution and diluted with 99 times its volume of water free from ammonia. This solution contains 1 part of Nessler in 100,000 or 100 milligram in each cubic centimeter.
Alkaline Permanganate Solution. It is made by dissolving 200 grams of solid potash and 8 grams of crystallized permanganate of potash in a litre of water, the solution boiled for some time in order to get rid of all traces of ammonia, while about one quarter of the liquid has been boiled away, sufficient water free from ammonia is added to bring the volume up to a litre. Each water analysis requires one of the solution.

Water free from Ammonia

Prepared by using a copper still, filling with ordinary well water, making slightly alkaline with pure sodium carbonate, and distilling. The first quart is that came over usually contained all the free ammonia, so that the remainder down to the last litre was practically free.

Reagent for the Determination of Chloride.

Standard Solution of Silver Nitrate. Was prepared
by dissolving 1.7887 gram of pure recrystallized silver nitrate in one litre of distilled water. This solution is of such a strength that one cubic centimeter is capable of precipitating exactly one milligram of chloropicrin. 

Dissolved 15 grams of the pure salt in 300 cc distilled water and added slight to the solution until a permanent red precipitate formed which carried down any Ca in the solution, then filtered.

Reagents for Determination of Hardness.

Soap Solution

Made a solution soap solution with methyl and methyl alcohol of such a strength that 18 cc of the solution would just form a permanent lather with 100 cc of a prepared Calcium Chloride solution of definite strength, or water of 8° hardness.

Reagents for Determination of Oxygen Consumed.
Standard Potassium Phosphate Solution. Dissolve 0.395 gram of the pure crystalline salt in water and make the solution up to 1 litre. 1 cc = 0.001 gram of the salt.

Ammonium Perbromate Sulphate Solution. Made by dissolving 10 g of the salt in 1 litre of water.

Hydrogen Sodicum Carbonate Solution. Made by dissolving 20 gr. of hydrogen sodicum carbonate in 250 cc distilled water or a 10 % solution.

Reagents for Nitrites. Made a strong saturated solution of caustic potash, and used with Alumininum foil.

Reagents for Determination of Nitrites. Made a dilute 1% solution 1-14. Used also a saturated solution of sulphanalic acid, and a saturated solution of 74% dichloride of Naphthalein.

The determinations were made as follows.
To determine the "free Ammonia" take 500 cc of the sample and if necessary make alkaline with Chemically pure sodium carbonate, although for water in this locality the addition of the sodium carbonate is in most cases unnecessary. Distill until all the "free ammonia" comes over, catching the distillate in a measuring flask. Continue the distillation until 500 cc caught in a receivers tube shows no coloration when the addition of 1 cc of the Nessler solution. The first distillate is then neutralized by adding 10 cc of 10% HCl solution. Then take 500 cc of water free from ammonia and add sufficient quantity of the Standard Ammonium Chloride solution and finally 1 cc Nessler solution. The Ammonium Chloride solution is made of such strength that by pointing off one place from the number of cc. used will give the parts per million of the free ammonia contained in the sample.
The "Uncumbed Ammonia" is determined from the residue by adding 5cc. alkaline permanganate solution and continuing the distillation. The alk. ammonia will usually come over in the first 5cc., it is caught and divided as in the preceding case.

"Chlorine" is determined by heating 10cc. of the sample with the standard silver nitrate solution, adding chromate of potash first from Cl. as an indicator. The chromate makes the reaction more delicate because of the fact that as soon as all the Cl. combines with the silver which always does so at first, forming a white ppt, then silver chromate is formed at which it is red. But no silver chromate is formed as long as chlorine is present. An important precaution here is that neither the silver nitrate nor the sample of water must contain acid, and if such is the case sodium carbonate must be added as silver chromate is soluble in acids.
Determination of Oxygen Consumed

Place in two 250 cc flasks 100 cc and 200 cc respectively, the sample being filtered if necessary, add to each 2 cc of a 10% solution of NaOH. Then add 5-10 or 15 cc of standard solution of potassium permanganate. The quantity of the KMnO₄ added should always depend on the time required by the alkaline solution due to exactly the same amount as added to each flask. Now boil the liquids side by side exactly 10 minutes and should they or either of them become yellowish, the quantity of permanganate added is insufficient, and it is necessary to repeat the above operation using more KMnO₄. Since the KMnO₄ attacks attacks different organic matters differently, the liquids are always boiled 10 min. After cooling there will be found in the flasks a flocculent deposit of brownish yellow manganese hydroxide. Acidify each liquid with 3 cc cone. H₂SO₄, and immediately thereafter add 40 cc glacial
Acid solution of ammonium ferrous sulphate. The decoloration is rapid, but the disappearance of the last traces of the deposit of manganese is slower. When the liquids are perfectly transparent, titrate side by side with normal H₂MnO₄. Then as the two will run under precisely similar conditions except that one flask contained 10 cc while the other contained 100 cc, the difference in volume of H₂MnO₄ used in the titration of the two gives the quantity of H₂MnO₄ corresponding with 100 cc of the water used in the analysis. Knowing the value in weight of 1 cc of the H₂MnO₄ deduce the weight of O. used by the organic matter dissolved.

Sequence of operations simultaneous.

Take 100 cc water
add 3 cc H₂SO₄
10 cc H₂MnO₄
Boil 10 min.
Cool
add 3 cc H₂SO₄ Conc.
1 cc H₂O₂
Feritrate with H₂MnO₄

Take 300 cc water
add 6 cc H₂SO₄
10 cc H₂MnO₄
Boil 10 min.
Cool
add 3 cc H₂SO₄ Conc.
4 cc H₂O₂
Feritrate with H₂MnO₄.
Determination of Nitrate. 50 cc of the sample are to a saturated solution of KOH free from ammonia, nitrates and etc. is added. Then a strip of aluminum foil is placed in the cylinder, and it is set away until the reaction ceases. By the reaction potassium aluminate is formed together with free hydrogen which reduces the Nitrate. A portion of this solution is then neutralized as in the case of the free and all ammonia.

Determination of Hardness. 100 cc of the sample is titrated with the standard soap solution adding 10 to 2 cc at a time and shaking thoroughly. The liberation is continued until a permanent deposit is formed on the wall which lasts upon standing 5 minutes. The degree of hardness is then calculated according to the table in Sutton, i.e., that 18 cc soap solution is 15 and every 2 cc soap sol. required above 18 cc equals 1° in hardness.
Determination of Nitrates. To 50cc of the water in a micro-
lever tube add 5 drops of dilute HCl; 6 drops of Sul-
phocyanic acid saturated solution and lastly 5 drops
of a saturated solution of hydrochloride of Naphthylamine.
The color produced will indicate whether or not nitrates
are present.

Total Solids were determined by evaporating 50cc of
the sample to dryness in a weighted platinum dish and
heating in an oven at a temperature of 100° until
the weight became constant. Then weigh and calculate
the number of grains per gallon by multiplying by 2 and
then by 0.000573.

Loss on Ignition is found by heating the solids in the plat-
imum crucible at a gentle heat of 500°C to dull redness for
some few minutes and then reweighing.

First are the results of some analyses of some native
water I analyzed in the fall and then again in the early spring.
Fell Analyser. Results are in parts per million except solids which are calculated in grams per gallon.

<table>
<thead>
<tr>
<th>Source and Surroundings</th>
<th>Fe Mt.</th>
<th>Al Mt.</th>
<th>White Mt.</th>
<th>O. Cn.</th>
<th>C.</th>
<th>Hardness</th>
<th>Solids</th>
<th>Colour</th>
<th>Solubility</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. U.P. Source - good</td>
<td>trace</td>
<td>.845</td>
<td>.31</td>
<td>3.4</td>
<td>.20</td>
<td>27.7</td>
<td>White</td>
<td>fair</td>
<td></td>
<td>For whole analysis indicates a good water.</td>
</tr>
<tr>
<td>2. Farm. Depth 30 ft.</td>
<td>.026</td>
<td>.088</td>
<td>.16</td>
<td>.6</td>
<td>14</td>
<td>19</td>
<td>36</td>
<td>Brown</td>
<td></td>
<td>Fair. Colour is high.</td>
</tr>
<tr>
<td>4. Farm. Depth 20 ft.</td>
<td>.125</td>
<td>.25</td>
<td>.30</td>
<td>.185</td>
<td>82.6</td>
<td>16</td>
<td>80.6</td>
<td>Black</td>
<td></td>
<td>Too much iron. Good.</td>
</tr>
<tr>
<td>5. Depth 50 ft. - good</td>
<td>.01</td>
<td>.106</td>
<td>.7</td>
<td>2.6</td>
<td>14</td>
<td>26</td>
<td>White</td>
<td>Good</td>
<td></td>
<td>Good.</td>
</tr>
</tbody>
</table>

Spring Analyses of the same water.

<table>
<thead>
<tr>
<th>Source and Surroundings</th>
<th>Fe Mt.</th>
<th>Al Mt.</th>
<th>White Mt.</th>
<th>O. Cn.</th>
<th>C.</th>
<th>Hardness</th>
<th>Solids</th>
<th>Colour</th>
<th>Solubility</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>.12</td>
<td>.125</td>
<td>.4</td>
<td>.4</td>
<td>2</td>
<td>4.4</td>
<td>18</td>
<td>White</td>
<td></td>
<td>Good.</td>
</tr>
<tr>
<td>2.</td>
<td>.039</td>
<td>.05</td>
<td>.47</td>
<td>.65</td>
<td>9.6</td>
<td>16</td>
<td>88.9</td>
<td>Brown</td>
<td></td>
<td>Fair.</td>
</tr>
<tr>
<td>3.</td>
<td>.11</td>
<td>.23</td>
<td>.22</td>
<td>.5</td>
<td>5</td>
<td>15</td>
<td>31</td>
<td>White</td>
<td></td>
<td>Fair.</td>
</tr>
<tr>
<td>4.</td>
<td>.145</td>
<td>.29</td>
<td>.27</td>
<td>.7</td>
<td>31</td>
<td>17</td>
<td>32.6</td>
<td>Black</td>
<td></td>
<td>Condensed. Water is good.</td>
</tr>
<tr>
<td>5.</td>
<td>.04</td>
<td>.19</td>
<td>.34</td>
<td>2.1</td>
<td>4.3</td>
<td>15</td>
<td>27.9</td>
<td>White</td>
<td></td>
<td>Good.</td>
</tr>
</tbody>
</table>
The results of the analyses of three waters, made both in the spring and fall, seem to indicate that as a general thing Free Ammonia is present in greater, not early spring; Albumenoid ammonia present in some greater quantity and the Oxygen Consumed is greater, while Nitrates are in most cases present in less quantity in spring than in the fall.

It is probable that the Free and Albumenoid Ammonia are present in greater quantity because the temperature in winter is not sufficiently high to cause the rapid oxidation of these materials into Nitrates. Further, because there is no growing vegetation to consume any of these materials when the ground is frozen this is most likely true since it has been proved by experiments that vegetable growths do take place at the expense of both the free and albumenoid ammonia, with few exceptions Nitrates will found in
less amount in the spring. Nitrate are the small products foundation of organic matter and as we assumed before, oxidation not taking place readily in the cold season and hence leaving the free and albumenoid ammonia to exist in greater quantities would be a possible cause why the nitrates were less. It is easier to account for the greater amount of oxygen consumed in the cold season, since as shown before greater quantities of undecomposed organic matter as "gum" and albumenoid ammonia exist in the spring and requiring for its oxidation increased quantities of oxygen.

The results of the other analyses made will be found on the next page.
<table>
<thead>
<tr>
<th>Surface Change</th>
<th>Final Altitude</th>
<th>Negative Motions</th>
<th>O.B.</th>
<th>Chlorine</th>
<th>Fastness</th>
<th>Color</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>go to depth: 50ft</td>
<td>0.1</td>
<td>1/8</td>
<td>1</td>
<td>none</td>
<td>1.2</td>
<td>2.1</td>
<td>11°</td>
</tr>
<tr>
<td>Depth 50ft. marlstone</td>
<td>0.6</td>
<td>7/8</td>
<td>3</td>
<td>trace</td>
<td>1.7</td>
<td>3.6</td>
<td>13°</td>
</tr>
<tr>
<td>Location: go to 40ft</td>
<td>0.15</td>
<td>3/1</td>
<td>15</td>
<td>none</td>
<td>0.26</td>
<td>2.6</td>
<td>14°</td>
</tr>
<tr>
<td>Raw</td>
<td>0.3</td>
<td>0.8</td>
<td>4.97</td>
<td>trace</td>
<td>.5</td>
<td>9.8</td>
<td>16°</td>
</tr>
<tr>
<td>Filt.</td>
<td>0.2</td>
<td>0.45</td>
<td>none</td>
<td>2</td>
<td>4.4</td>
<td>12°</td>
<td>32.9</td>
</tr>
<tr>
<td>70 ft. High</td>
<td>0.45</td>
<td>0.2</td>
<td>0.71</td>
<td>trace</td>
<td>.7</td>
<td>26.2</td>
<td>26°</td>
</tr>
<tr>
<td>Depth from here to 200ft.</td>
<td>1</td>
<td>0.25</td>
<td>10</td>
<td>trace</td>
<td>.2</td>
<td>3.9</td>
<td>9°</td>
</tr>
<tr>
<td>Depth 200ft.</td>
<td>1.3</td>
<td>0.21</td>
<td>2.4</td>
<td>none</td>
<td>1.4</td>
<td>15.9</td>
<td>22°</td>
</tr>
<tr>
<td>Very good</td>
<td>.11</td>
<td>.14</td>
<td>none</td>
<td>.6</td>
<td>6.5</td>
<td>16°</td>
<td>brown.</td>
</tr>
<tr>
<td>60 ft. Deep</td>
<td>0.08</td>
<td>.1</td>
<td>1.9</td>
<td>trace</td>
<td>1.4</td>
<td>2.2</td>
<td>18°</td>
</tr>
<tr>
<td>Depth, good Surround.</td>
<td>none</td>
<td>.01</td>
<td>1.35</td>
<td>none</td>
<td>.2</td>
<td>4.26</td>
<td>16°</td>
</tr>
<tr>
<td>Surroundings not dry.</td>
<td>0.21</td>
<td>0.08</td>
<td>7.2</td>
<td>slight</td>
<td>1.2</td>
<td>8.2</td>
<td>21°</td>
</tr>
<tr>
<td>Again well bored up</td>
<td>1.65</td>
<td>0.88</td>
<td>7.3</td>
<td>good trace</td>
<td>3.6</td>
<td>8.9</td>
<td>24°</td>
</tr>
<tr>
<td>This well is the 22nd</td>
<td>Depth Water not now used</td>
<td>1.45</td>
<td>0.2</td>
<td>2.6</td>
<td>good trace</td>
<td>7.3</td>
<td>12.4</td>
</tr>
<tr>
<td>Surroundings fine</td>
<td>trace</td>
<td>.18</td>
<td>.9</td>
<td>none</td>
<td>.16</td>
<td>2.0</td>
<td>18°</td>
</tr>
<tr>
<td>Depth 165 ft. Iron pipe</td>
<td>2.16</td>
<td>.01</td>
<td>none</td>
<td>none</td>
<td>.16</td>
<td>2.6</td>
<td>29.7</td>
</tr>
</tbody>
</table>
The significance of the presence of these different substances.

"Free Ammonia" shows the presence in water of organic material in process of decomposition and although not in
finite proportion of this ingredient which a water suitable
for domestic purposes can be stated: yet the presence
of larger quantities than 1 part per million should
not be looked upon with favor. All other determinations
should be taken into account before a water is condemn
ed as well as the general surroundings. The best
water contains none or but a trace, while it is always
found in waters which receive house drainage.

In the analysis of a water from a very deep well (Crot
as given in the table very large quantities of free am-
monia were found, in fact more than was found in
very poor wells of shallow depth. Another curious thing
is that no nitrate was found. An explanation of this
is offered in the Massachusetts Report, to the effect that
nitrate will decomposed on passing through the deep soil by the metallic sulphides, free ammonia being formed. "Albuminoid Ammonia" represents the Nitrogen which exists in organic combination before decomposition has set in. The determination of albuminoid ammonia does not in itself give us much information as to the character of the organic matter. So that standards of purity based simply on the amount of albuminoid ammonia are of little value since it is the quality rather than the quantity which is of importance. "Mass. Report 1890, Page 525.

The liability of organic matter to decay and whether it is of animal or vegetable origin are the things that are essential if present. There are kinds of organic matter found in waters which is very permanent and this is not necessarily detrimental. As for instance the brain waters which sailors often take on long voyages because they do not decompose so readily as ordinary waters.
Whether or not the albumenoid ammonia is from animal impurities can most always be told by a close inspection of the surroundings of the well, and also by the general results of the rest of the analysis. Another fact is that the albumenoid ammonia is found in excess of the free ammonia in normal water, where conditions usually indicate something abnormal. "Nitratie" and "Nitrite". The presence of Nitrate in waters shows that they once contained organic matter since oxidative takes place from the albumenoid ammonia first to Free Ammonia and Nitrites and finally to Nitrate. So that Nitrogen as permanent albumenoid ammonia, as in the case of the brown waters before mentioned or as Nitrate is the most favorable condition in which it can be present in water. While the free ammonia and the Nitrites are the most dangerous since they indicate the presence of organisms.
Producing decay and capable of producing deleterious effects on the body.

"Oxygen Consumed". The determination of the oxygen consumed in water is of great value in comparing waters of the same general character and origin, indicating in a measure the sum total of the organic matter. The test waters of this locality do not show more than a few tenths parts per million of oxygen consumed and never more than 1 to 2 parts per million if the sample is fit for use. The New Jersey Reports for 11 pages on regard to the value of the determination of oxygen consumed. "As some organic compounds which are almost permanent decompose readily with potassium permanganate and others which have a tendency to decompose are not affected by the potassium permanganate caution must be used in the conclusions in some cases." As was said before it is more valuable as a comparative list of value to others.
"Chlorine". Good water in this locality contains but small quantities of chlorine and when a sample is found which is devoid of chlorine or nearly so we are certain that it is free from sewage contamination, for urine and sewage always contain large quantities of chlorine usually as common salt. But the absence of chlorine is no guarantee against vegetable contamination. The time when the chlorine determinations in drinking wa-
ter are of the most service are when the general condi-
tion of the water of a neighborhood are known, it is re-
Quired to pronounce at once on the condition of a num-
ber of wells, for instance when there is an outbreak 
of some contagious disease. At such a time the rapid 
chlorine determination would be of inestimable value.
"Total Solids". The solid matter depends on the soils, the rocks 
and etc. with which the water come in contact. Lime and 
Magnesia are readily dissolved by water going into
Solution as decarbonates. The hardness depends on the amount of lime and magnesium in solution as these two salts form a curd with the soap and prevent the formation of a lather until they have combined with the fatty acid of the soap. Excessively hard water is liable to cause impairment of the mucous membrane lining the digestive tract. According to the Brussels Commission of a few years ago the total solids of a good drinking water should not exceed 85 grains per gallon. and a water in which the solids are under 25 grains per gallon is better.

Lesson 10: The difficulty of heating the residue to the proper degree to burn off the organic matter without decomposing some of the volatile mineral salts makes the determination of loss on ignition of minor importance as long as the different determinations of nitrogen are made anyhow. The color however assumed.
by the solid residue upon heating is of great signif-
ificance. If a dark color is at first produced upon
heating, it shows the presence of much organic matter
and when the color is black upon first heating most
excessive quantities of organic contamination are present
and a careful and complete examination will likely con-
demn the same.

Lastly I would repeat that the interpretation of a
chemical examination or analysis of a water must be
made on the analysis as a whole and not on any single
determination. For take, for instance free ammonia which
is recognized as a good sign of sewage contamina-
tion has been found in sufficient quantity to render
a normal water and again under certain condi-
tions sewage polluted waters have failed to show
any notable traces of free ammonia. Such facts
do not detract from the value of the chemical
Analysis but simply show how easy a mistake may be made. In all cases where the analyses are taken as a whole together with a knowledge of the location of the well, there should not be much uncertainty as to the interpretation.