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# The Drinking Waters of Dakota

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# DAKOTA AGRICULTURAL COLLEGE AND EXPERIMENT STATION,

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## DEPARTMENT OF CHEMISTRY.

### THE DRINKING WATERS OF DAKOTA.

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This Bulletin is issued preparatory to a thorough investigation of the characteristics of the drinking waters of Dakota. A few analyses are given, together with other information that will place this subject before the citizens of Dakota in a manner likely to bring to the Station trustworthy samples of water accompanied by correct and explicit data.

Samples of drinking water (good as well as bad) are needed for the completion of this work and all such will receive prompt attention. A few samples from widely separated localities are desired rather than many samples from the same locality.

The analyses will be made free of charge, under proper restrictions as explained in the accompanying application for analysis, and any desired advice will be cheerfully given.

The work in water analysis will be resumed immediately after the 1st of March, 1889. It is necessary that samples of water should be sent after that date since water spoils by keeping.

Other Bulletins upon forestry, fruit growing, corn culture, extermination of insect pests, analysis of water and soils will speedily follow.

Any farmer in the territory who desires the Bulletins of the Station can have them mailed free to him by sending in his address.

The press of the territory can do a favor to the Station and to the people by giving this notice wide publicity.

Correspondence is also invited upon any question relating to farm interests. Questions relating to farm crops or stock should be addressed to Prof. Foster; questions relating to tree culture or to gardening should be addressed to Prof. Keffer; questions relating to insects should be addressed to Dr. Orcutt; questions concerning the chemical composition of soils or waters should be addressed to Prof. Shepard, and questions about the diseases of animals and their treatment should be addressed to Dr. Alloway,—all at Brookings, Dakota.

LEWIS McLOUTH, Director.

# Department of Chemistry.

JAS. H. SHEPARD, Chemist.

## THE DRINKING WATERS OF DAKOTA.

In this Territory, as in all newly settled regions, there are many important problems awaiting chemical investigation. Among those claiming more immediate attention here is an examination of our potable waters. Reliable information on this subject will be of value alike to the present land owner and to the prospective immigrant. Certain other reasons would seem to warrant an early investigation. For instance, an unfortunate and incorrect use of the word "Alkali" has undoubtedly given the waters of some sections an undeservedly bad reputation. Again some wells present unusual phenomena of odor, taste, etc., at various times; while the question of wholesomeness is always a pertinent question.

Influenced by these and other considerations of importance to the Territory in general, the Station has decided to issue this preliminary Bulletin, confident that the general and common interest of all concerned will warrant the investigation. Moreover a wish and invitation is hereby conveyed that samples of drinking water, together with accurate data be forwarded to the Station so that the work may reach a successful completion.

At the outset there are many questions that naturally arise. Among these questions we may indicate a few as follows: Are any or all of our drinking waters wholesome? Have we true "Alkali" waters and if so in what sections? What are the causes of the changes that occur in the waters in some wells in various localities, and what may be done to remedy this evil? What variations do the waters of different localities present? Etc., etc.

It matters little which one of these be considered first, therefore the question of wholesomeness will answer as well as any.

The first sample analyzed came from the well of President McLouth, situated about forty rods west of the college buildings at Brookings. This well was dug in November, 1887, and completed in May, 1888. It is curbed with twenty-eight inch glazed tiling and

passes through the ordinary prairie soil and subsoil, and then through a gravelly clay to a depth of thirty-eight feet, ending in the same kind of clay. The well was dug four inches wider than the tile and the space around the tile was rammed with clay excavated from the well. The well carries about fifteen feet of water and is provided with an iron pump. The barn and out building are not over one hundred feet distant, but owing to the manner in which the well is constructed and to the thick bed of clay through which the well passes, there is little opportunity for surface contamination, unless indeed, the cracks and seams of the subsoil clay extend to a greater depth than they probably do. Upon this point no information is procurable. The water of this well has always been sweet and to all appearances wholesome.

In passing, it might be well to mention that in digging a well special note should be made of the seams, cracks, etc., to be found in the clay through which the well passes. It is true that these seams may be filled with sand, but still a passage for surface water may thus be afforded. Where these seams extend deeply the barns and outbuildings should be placed as far away as possible. No certain distance can be assigned as a safe one since all this depends upon the nature of the strata through which the well is sunk.

Following is the analysis of sample 1:

ANALYSIS.

A sample of drinking water sent by Lewis McLouth, Brookings, Dakota. Sample received November 13th, 1888. Color, clear. Odor, none. Taste, pleasant. Analysis completed November 19th, 1888.

| DETERMINED. | PARTS PER MILLION BY WEIGHT. |
|---|---|
| 1. Permanent Hardness | 85. |
| 2. Temporary Hardness | 55. |
| 3. Total Hardness | 140. |
| 4. Chlorine | 15. |
| 5. Nitrites | None. |
| 6. Free Ammonia | .052 |
| 7. Albuminoid Ammonia | .044 |
| 8. Total Solids at 110 °C. (230 °F.) | 412. |

Qualitative tests on total solids show:—Bases—Calcium, Magnesium, Aluminum, Iron, Sodium and Potassium. Acids—Carbonic, Sulphuric, Hydrochloric, Silica; Probable Salts are chiefly Calcium Carbonate and Sulphate, Magnesium Sulphate, Ferrous Carbonate and Sodium Chloride.

Remarks.—This is a very good water and perfectly wholesome.

Note.—A good drinking water should not contain over .08 parts per million of Albuminoid Ammonia and little or no Nitrites. It should be borne in mind that the waters of Dakota are capable of extracting vegetable matter from wood and other organic substances, and that great care should be exercised in keeping the water free from organic pollution.

Explanation of terms used in analysis:

1. By hardness is meant any salt that will curdle soap. Among such substances may be named calcium carbonate or common limestone, magnesium sulphate or Epsom salts, calcium sulphate or gypsum, etc. By permanent hardness is meant hardness that cannot be removed by boiling. In the analysis given the permanent hardness is reported in equivalent to carbonate of lime.

2. Temporary hardness means hardness that may be removed by boiling. In the samples so far examined the temporary hardness is equivalent to the carbonate of lime or calcium carbonate present in the sample.

3. The total hardness is evidently the sum of the permanent and temporary hardness. Very hard waters often carry as high as 5000 parts per million.

4. By Chlorine is meant the chlorine occurring in combination with such metals as sodium, thus forming common salt, with calcium forming calcium chloride, with magnesium forming magnesium chloride, etc. It is not easy in the case of the waters examined to set a limit to the amount of chlorine that may thus occur without becoming detrimental. It is evident that the soils of Dakota contain small quantities of common salt that naturally enough find their way into the drinking waters; and of course common salt is not detrimental unless present in sufficient quantities to become apparent to the taste. The reason why this determination is always made is that sewage always carries large proportions of chlorides, and when the salt occurring naturally in the soils has been determined, any excess must be due to sewage pollution.

5. Nitrites are always a product of decomposition or of so called nitrification that takes place only in the presence of decaying organic matter. Consequently the presence of any considerable quantities of nitrites must be regarded as suspicious. The word "trace" as used by the chemist signifies that there are not sufficient quantities of the substance to admit of an estimation.

6. Free ammonia means ammonia that finds its way into drinking water from rains or from vegetable matter that has undergone complete decomposition. A good water may carry from .01 to .08 parts of free ammonia per million, depending upon other characteristics.

7. Albuminoid ammonia is a term used by chemists to signify the ammonia that is obtained from albuminoid or nitrogen bearing organic compounds, by the process to which they subject the water. It is therefore a measure of the undecayed and decaying organic matter contained by the water. A good water should not show more than .08 parts per million.

8. The total solids are obtained by evaporating the water to dryness and weighing the residue. In the analyses given the residue was dried at a temperature somewhat above the boiling point as indicated. A very good drinking water may carry as high as 600 parts per million of total solids and be none the worse for it, provided, of course none of the constituents are positively injurious. And under

the same conditions there is no certainty that the amount may not rise several times higher.

While it confessedly does not lie within the province of the chemist to pronounce upon such subjects, still it may not be out of place here to say that the total solids of the samples thus far examined show no mineral ingredients that would affect the healthy system injuriously, while on the contrary in many cases these salts would have a slight though positive medicinal value.

The second sample examined came from a neighborhood where the waters are said to have a doubtful reputation. This well, however, according to the belief of its owner is good, and personally he does not think that the waters of that region should be condemned without a fair and accurate investigation. Neither this gentleman nor his wife has suffered any inconvenience from its use. The well is about twenty-four feet deep and is in clay ending in clay and sand. The well is curbed with pine and the water is drawn by means of a bucket. Following is the analysis sample 2:

ANALYSIS.

A sample of drinking water sent by Joseph Ladd, Town 107, Range 50, Moody County, Dakota. Sample received September 24th, 1888. Color, clear; odor, none; taste, pleasant. Analysis completed November 20th, 1888.

| DETERMINED. | PARTS PER MILLION BY WEIGHT. |
|---|---|
| 1. Permanent Hardness | 200. |
| 2. Temporary Hardness | 35. |
| 3. Total Hardness | 235. |
| 4. Chlorine | 16. |
| 5. Nitrites | Traces |
| 6. Free Ammonia | .028 |
| 7. Albuminoid Ammonia | .088 |
| 8. Total Solids at 110 ° C. (230 ° F.) | 601. |

Qualitative tests on total solids show:—Bases—Calcium, Magnesium, Sodium, Iron, Aluminum; Acids—Carbonic, Sulphuric, Hydrochloric, Silica; Probable Salts are chiefly Calcium Carbonate, Magnesium Sulphate, Sodium Chloride, Ferrons Carbonate.

Remarks.—This is a fair water although the organic matter is too high. A stone or tile curb would improve the well.

There is nothing in this sample to give any one cause for alarm. In all probability were the well as perfectly constructed as in sample one, the organic matter would be reduced below the amount permissable. There can be no doubt that the pine curbing itself yields to the water a very considerable amount of organic matter. Farther, it is very likely that if the farmers in this neighborhood would dig their wells deeper, and would curb them with stone, tile or brick, cementing the curbing perfectly in order to shut off all surface impurities, there would be no trouble in having excellent water in the

whole neighborhood. Of course it would be necessary to dig deep enough below the clay to prevent access of surface pollution and the water bearing vein must come from below the clay. A little money judiciously invested in this direction would yield large returns in this district.

The next sample examined came from The Little Grove Farm, Flandrau. Concerning this well Mr. Perley writes: "Water was struck in this well at twelve feet, a weak vein in sand and sand and clay mixed, three feet in depth. Below this stratum is a reservoir in nearly pure clay, five feet in depth. The bottom is artificially covered with sand and gravel to a depth of three inches. The well is curbed with pine, about three and one-half feet square, from which we draw the water with a chain pump. The well has been in use for about five years. It is full nearly to the top every Spring on account of the large drifts of snow in the grove about the house and well, and barely affords enough water for the house in Mid-winter. It has not been cleaned out since last Fall. When cleaned out the gravel is covered over with an inky black sediment of quite a repulsive odor. The water limes over the tea-kettle and eats up tin-ware and is not so palatable after it stands a while as good water ought to be. I have been afraid that in time it might affect our health."

This sample stood too long before it was possible to analyze it and at the time the analysis was made no data were at hand. The analysis of sample 3 follows:

### ANALYSIS.

A sample of drinking water sent by G. A. Perley, Flandrau, Dakota. Sample received August 16th, 1888. Color, clear; odor, none; taste, slightly saline. Analysis completed November 21, 1888.

| DETERMINED. | PARTS PER MILLION BY WEIGHT. |
|---|---|
| 1. Permanent Hardness | 284. |
| 2. Temporary Hardness | 165. |
| 3. Total Hardness | 449. |
| 4. Chlorine | 135. |
| 5. Nitrites | Traces |
| 6. Free Ammonia | .034 |
| 7. Albuminoid Ammonia | 1.644 |
| 8. Total Solids at 110° C. (230° F.) | 940. |

Qualitative tests on total solids show:—Bases—Calcium, Magnesium, Sodium, Iron, Potasium; Acids—Sulphuric, Carbonic, Hydrochloric; Silica; Probable Salts are chiefly Calcium and Magnesium Sulphate, Calcium Carbonate, Sodium Chloride, Ferrons Carbonate.

Remarks.—This sample contains twenty times too much organic matter, and is not safe to use. Sample stood too long before analysis.

The enormous amount of organic matter present as shown by the Albuminoid Ammonia reported indicates that this is a surface, shallow well, and Mr. Perley's description confirms that suspicion. It is quite certain that the water vein lies on top of the impenetrable clay stratum

instead of under it as the vein should be. It is quite likely that if Mr. Perley should do as Mr. Kemp has done (see next sample) he would have a good well without much further expense. This well should not have a wooden curbing and the water should be drawn with a bucket or an iron pump.

There is one thing about these shallow wells that is not very well understood, and that is, not only is the quantity of water fluctuating but the quality fluctuates as much as the quantity. For example in the earlier part of the season, after heavy rains and snow, the organic matter is greater and the mineral matter less, while in the latter part the organic matter decreases while the mineral matter increases. This may best be shown by the following determinations in a second sample kindly sent by Mr. Perley. This sample was taken from the same well December 3d, and analyzed December 6th, 1888. Only three determinations were made simply to illustrate this point.

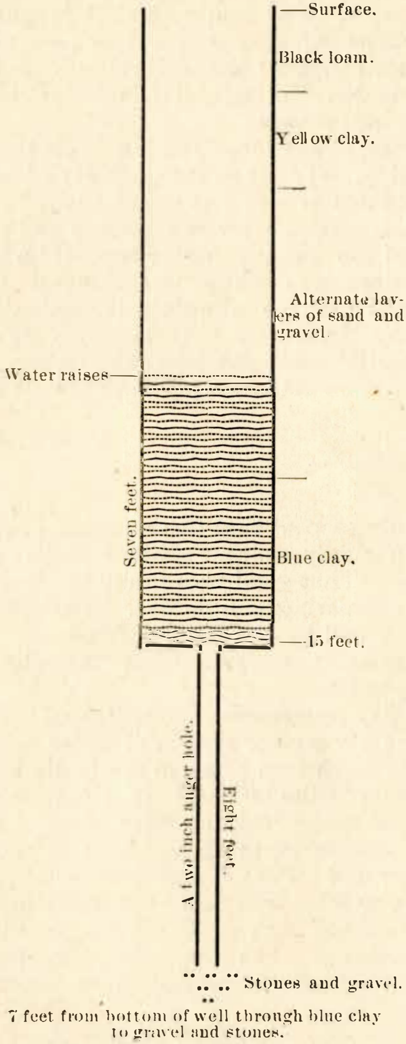
| | |
|---|---|
| Free Ammonia | .015 |
| Albuminoid Ammonia | .112 |
| Total Solids | 1206. |

One would hardly suspect that these samples came from the same well. In this well one may see that shallow wells at certain times may yield bad water. That good water may be had in this region may be learned by comparing sample five. The odor and the effect of this water on tinware will be discussed further on.

The next sample analyzed came from Watertown. Concerning this well Mr. Kemp writes:

"I send you to-day by express two gallons of water from the well on my farm. I have a complete system of water works, pumping with an iron pump and through iron pipes to my house and my two barns. The water has tasted a "trifle off" and my wife insists that the water is not good; so we are using from another well. I would like to know if the water contains anything injurious to health, (and its effect on the stomach, liver and kidneys) and if so what can be done to remedy the evil. Also what will make the water fit for laundry purposes. The well is curbed with wood. I can put in a new curbing and cement it if necessary. The jug sent contains water pumped through the iron pipes to the house just as we would use it if the water were all right.

"The well is a peculiar one and I make you a diagram of it in order to show you exactly how it is made. The well was dug, as shown, through the different strata until we had penetrated seven feet into blue clay. We then took a common two-inch auger and bored down through the blue clay, a distance of seven or eight feet when we struck a stone. We pulled up the auger and the water followed until it stood seven to twelve feet above the top of the auger hole. There is an abundance of water and we can never pump it dry."




The analysis of sample 4 is as follows:

ANALYSIS.

A sample of drinking water sent by Hon. Oscar P. Kemp, Watertown, Dakota. Sample received November 30th, 1888. Color, slightly turbid; odor, none; tastes slightly of iron. Analysis completed December 3, 1888.

| DETERMINED. | PARTS PER MILLION BY WEIGHT. |
|---|---|
| 1. Permanent Hardness | 172. |
| 2. Temporary Hardness | 234. |
| 3. Total Hardness | 406. |
| 4. Chlorine | 13. |
| 5. Nitrites | Traces |
| 6. Free Ammonia | .02 |
| 7. Albuminoid Ammonia | .066 |
| 8. Total Solids at 110° C. (230° F.) | 644.8 |

Qualitative tests on total solids show:—Bases—Calcium, Magnesium, Iron, Sodium; Acids—Carbonic, Sulphuric, Hydrochloric; Silica; Probable Salts are chiefly Calcium and Ferrons Carbonate, Magnesium Sulphate, Sodium Chloride.

Remarks.—A good water; slightly laxative; no injurious effects on kidneys, etc. One pound of potash lye (Lewis' lye) will soften 171 gallons of the water. Allow the precipitate made by the lye to settle over night. When a new curbing is needed use stone, tile or brick, cementing carefully.

An inspection of this analysis shows that there is nothing wrong with this water. The taste mentioned is due chiefly to the iron in the water and would exert no deleterious influence on the digestive tract, nor upon the liver or kidneys. It is probable that this water as well as all the samples examined are slightly laxative and would prove of some value in such disorders as congestion of the liver and in hemorrhoids, by relaxing the portal systems of vessels. But the fact must again be insisted on that the quantities of mineral salts are too small to have a decided medicinal effect. It should suffice to know that good health would not be impaired by their use.

In regard to softening this water, it was found that if the water was used immediately after adding the lye, while the precipitate was still suspended, that the precipitate curdled the soap, thus necessitating a larger quantity of lye. By allowing the precipitate to subside the water was softened perfectly without any great excess of lye. This fact will prove valuable since many object to the use of lye as an excess of it chaps the hands. The lye should first be dissolved in water and then added to the water to be softened and thoroughly mixed with it, allowing the precipitate about twelve hours to settle.

Sample No. 5 comes from a well situated about twenty rods distant from the one which furnished sample No. 3. Concerning this Mr. Perley writes:

"I feel quite confident that this water will give a more wholesome analysis. The well is curbed with pine about four feet square and twenty-seven and a half feet deep. It passes through five feet of sand and gravel at the bottom and this extends much deeper below the bottom of the well. The pump is iron and thirty head of stock are watered daily at the well, which draws the water to within about two feet of the bottom of the well. It has been used three years. We are about 150 feet above the level of the Sioux river and 1600 feet above sea level."

ANALYSIS.

A sample of drinking water sent by G. A. Perley, Flandrau, Dakota. Sample received December 5th, 1888. Color, clear; odor, none; taste slightly saline. Analysis completed December 6, 1888.

| DETERMINED. | PARTS PER MILLION BY WEIGHT. |
|---|---|
| 1. Permanent Hardness | 620. |
| 2. Temporary Hardness | 240. |
| 3. Total Hardness | 860. |
| 4. Chlorine | 13. |
| 5. Nitrites | None. |
| 6. Free Ammonia | .02 |
| 7. Albuminoid Ammonia | .06 |
| 8. Total Solids at 110° C. (230° F.) | 2686. |

Qualitative tests on total solids show:—Bases—Calcium, Sodium, Magnesium, Aluminum, Iron; Acids—Sulphuric, Carbonic, Hydrochloric Silica; Probable Salts are mostly Calcium Sulphate and Carbonate; small quantities of Magnesium Sulphate, Sodium Chloride and Ferrons Carbonate.

Remarks.—A bright wholesome water; rather hard. No doubt in the absence of wood the organic matter would be even less.

This sample was gladly analyzed as it might throw some light on the question as to whether the waters are all bad around Flandrau. From the analysis it appears that the water is good, and from the depth of the well the inference is inevitable; by going deeper good water may be found, and this is probably true of all localities from which samples have come.

So far it seems that wells with pine curbing and wells drawing their supply from above the clay are liable to contamination. But it must be remembered that these investigations have only been commenced. Many more samples from other localities are needed and no doubt will soon be forthcoming.

## ARE OUR DRINKING WATERS "ALKALI WATER?"

In reply it can only be said that up to this date not one sample of alkali water has reached the Station. If anyone thinks he has alkali water it is earnestly to be hoped that he will forward it to the Station and thus only can the question be satisfactorily settled.

## WHAT CAUSES THE ODORS THAT SOMETIMES APPEAR IN DAKOTA WELLS?

Complaints have come to the Station that soon after digging, usually from six months to a year, the waters of some wells develop an offensive odor, that a black sediment is deposited in the bottom of the well; and that the water eats up the tinware; and that the water deposits a gelatinous sediment; and that it foames when pumped. After a time the well seems to purify itself and the water becomes good again. Now what are the causes of these changes?

There may be one or more causes as follows: First, it may be some substance that is permanently in the soil and which is simply dissolved out by the water passing through it on the way to the well.

Again, it may be possible that the substance is in the soil and that it is only soluble in the presence of excesses of organic matter that at certain seasons are brought into the water veins by heavy rains and melting snows. Or once more, it may be that the pine curbing of the wells act on the sulphates occurring in the waters thus causing the changes; and these changes may be furthered by the action of organic matter in the water.

Of these hypotheses it seems that the latter would offer an explanation more likely to agree with the facts in the case than either of the others. In the first place were the substance simply dissolved out of the soil, the odor, etc. would be permanently in the water. There would be no periodical occurrences such as have been reported. Should the second hypothesis be taken, we cannot account for the fact that such wells as that from which sample one was taken, so far as observed, never exhibit such changes. Moreover one would expect to find these changes occurring at certain periods of the year and more especially in the Spring. Now such is not the case. So far as reports have reached the Station the change is liable to come at any time, even in the Fall or Winter when the organic matter is at a minimum.

Starting then with the last hypothesis the following Experiment was made with a sample of pure water taken from a well that had never exhibited any of these phenomena.

A gallon of water was taken from the well furnishing sample one. To about a pint of this water was added one ounce of pine shavings taken from a perfectly clean pine board. This mixture was boiled ten minutes and the liquid poured off. Thus was obtained a strong infusion of pine. This infusion was then added to the remainder of the gallon of water and the whole placed in a bottle, and tightly stoppered in order to prevent evaporation. The bottle was placed in a moderately warm place and examined from time to time.

Of course it is plain to be seen that the object of this experiment was to try to induce by artificial means the phenomena exhibited by this class of waters. The next step was to procure some samples of these offensive waters and examine them. Accordingly several samples were secured and the offensive odor was shown to be due to Sulphuretted Hydrogen. Perhaps, also some of this gas had combined with the free ammonia of the water, thus forming Ammonium Sulphide. Both these compounds have a most offensive odor. It is just and proper to state at this point that Sulphuretted Hydrogen is not injurious to health, in fact it is the principal ingredient of many famous medicinal sulphur springs.

Attempts were also made to procure some of the black sediment complained of, but with no success. The same was true of the gelatinous precipitate.

But to return to the experiment. In two days the water which was originally bright and clear assumed a dark yellowish color and smelled strongly of pine. In five days the water became cloudy and another odor began to develop, but no test for Sulphuretted Hydrogen

could be obtained. In eight days the color had deepened and the odor had increased perceptibly but no hydrogen sulphide had been developed. In ten days a gummy precipitate began to settle. In twelve days both odor and precipitate had increased to a marked degree. From this time till the experiment was brought to a close by the suspension of work in the laboratory, gradually increasing traces of sulphuretted hydrogen were developed. Upon emptying the bottle the water foamed as it was poured out. When half of the water had been emptied, the remaining half was thoroughly shaken up, when the bottle filled with foam. Moreover, a slight black precipitate, too small to work upon had been deposited. The gelatinous precipitate consisted chiefly of resinous matter that had been extracted from the pine shavings.

All the samples, so far examined, will rust tinware.

This experiment plainly shows that these waters examined at the Station do possess extractive properties and that a portion of the pine used for curbing is first dissolved and afterwards deposited as a gelatinous precipitate when the water has stood for some time. Again it shows that even the best of these waters become offensive under the same conditions. Again it offers great inducement to push this line of inquiry further. For this work samples of black residue are needed and it is to be hoped that parties interested, when cleaning out such wells will forward sufficiently abundant samples of this black precipitate to permit of an analysis.

If upon further investigation the pine curbings and wooden pumps can be shown to be responsible for these changes, every well owner in the territory can easily prevent all such annoyance in the future.

Samples of water from shallow wells not having wooden curbing or wooden pumps are needed to determine whether the organic matters of the soils can produce these changes. Again samples of water from deep wells, or at least those deriving their supplies from under the clay, about which wood is not employed, are also desired. Especially would the Station be glad to hear of any wells similar to Sample one, that have developed any unpleasant odors. Samples of the water are also desired. Again samples of deep waters where wood is used would be very acceptable, since it is possible that some such wells do not undergo a change.

There is one cautionary word that should be said here. Parties sending samples for any of these purposes must be very careful and exact in their statements, so that the Station can place the utmost confidence in the data given. It will not do to take anything upon hear-say, but every particular must be well authenicated.

Blank forms for the data desired may be had upon application.