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The Sanitary Analyses of Some Iowa Deep Well Waters

J. B. Weems

The following is the description of each of the eight strata in this pit, beginning with the top:

		Thickness in Feet.
D—1.	Clay, variegated	5
D—2.	Shale, streaked in color	4
D—3.	Shale, solid chocolate brown color, clear definition.	5
D—4.	Shale, solid color, clear to poor definition	5
D—5.	Shale, variegated, clear to poor definition	3
D—6.	Shale, sandy, solid color	10
D—7.	Shale, sandy, clear definition, solid color, granulated texture, pulverizes in the hand: thickness.	5
D—8.	Shale, gray, clear definition. This clay forms 38 to 40 per cent of the bank and runs to underlying coal	23

(4.) THE FLINT BRICK COMPANY is located in Oak Park upon the Des Moines river. Seven samples were analyzed from this pit. A complete description of the strata was not obtainable at the time the samples were taken.

THE SANITARY ANALYSES OF SOME IOWA DEEP WELL WATERS.

BY J. B. WEEMS.

In the investigation of deep well waters the interest in many cases has been limited to the mineral substances, and little attention given to the sanitary analysis. This is a natural result when it is realized that these waters contain large amounts of solids and the possibility of contamination by sewage or other products is very slight indeed. In connection with the work of the Department of Agricultural Chemistry of the Agricultural College, analyses of a number of samples of water from the deep wells of the state have been made and the results brought together in hope that they may be of interest. The methods used do not require any explanation as they are those which have been generally used for analyzing water. The oxygen

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absorption may, however, be given some attention, as this part of the analytical work has not reached a satisfactory position. The method of oxygen absorption used is what may be called the "English method" and was first proposed by the Association of Public Analysts of England and is outlined in connection with another investigation published recently.*

In the analyses of the deep well waters the amount of free ammonia at once attracts attention. This is not a new observation but has been recognized for some time as quoted by Mason.†

THE SANITARY ANALYSIS OF WATERS FROM SOME OF THE DEEP WELLS OF IOWA.

LOCATION.	Free ammonia.	Albuminoid ammonia.	Chlorine.	Solids on evaporation.	Nitrogen as nitrites.	Nitrogen as nitrates.	Oxygen consumed, 15 minutes.	Oxygen consumed, 4 hours.	Depth of well.
Amana	1.005	T	18.42	1088.57	0	0	.24	.264	1,640
Ames	.18	.024	51.00	1226.00	.4	T	.32	.48	2,215
Boone	1.4	.015	152.90	2047.14	0	0	.74	.74	3,010
Cedar Rapids	.86	.016	.43	592.90	.3	.16	.80	1.00	1,450
Centerville	.978	.02	388.60	4132.14	4.8	0	1.68	2.48	1,540
Davenport	1.10	.005	273.00	1192.86	0	0	.96	.99	
Dubuque	.02	T	T	288.57	0	0	.10	.45	
Holstein	.62	.036	21.70	1527.00	T	T			
Homestead	.95	.00	33.14	1088.57	0	0	.43	.64	2,2?4
Iowa Falls	.79	.068	12.00	446.00	0	0	6.10	9.10	
Keokuk (Pickle Co.)	1.22	.03	633.00	3637.14	.42	0	1.38	2.42	710
Keokuk (Poultry Co.)	1.50	.015	674.00	3727.14	0	0	.43	.75	700
Manchester No. 1	.05	.012	9.00	304.00	0	.9	......	....	(1)1,870
Manchester No. 2	.03	.06	80.00	499.00	0	.25	......	....	(2)1,870
McGregor well No. 1	1.25	.0175	967.90	2795.00	0	0	.68	2.49	1,006
McGregor well No. 2	.02	.01	36.00	372.86	0	0	.29	.50	502
Monticello	.013	.015	5.9	371.43	0	0	.46	.98	1,198
Newton	2.27	.186	183.00	4716.00	0	0	2.56	26.88	1,400
Sabula	.08	.006	T	295.71	0	0	.16	.62	973
Sioux City	1.25	.015	84.1	1617.14	0	0	.06	1.85	
Waverly	.49	.01	6.00	544.00	0	0	.2	1.4	
Webster City	.15	T	10.3	1051.43	0	0	.3	.9	1,250
West Bend	1.45	.01	5.71	681.43	0	0	.99	1.43	881

(1) 980 feet of casing.
(2) 1,300 feet of casing.

"The 'free ammonia' in artesian wells is often excessive, under circumstances that make animal contamination an impossibility, and even rain water, freshly collected after periods of long drought, will often exhibit properties calculated to mislead the analyst."

*Weems & Brown. Influence of Chlorine as Chlorides in the Determination of Oxygen Consumed in the Analysis of Water. Proc. Iowa Acad. of Sciences, 8. p. 87.

†Water Supply. p. 392.

The excessive amount of free ammonia in deep well water is accounted for by Fox* as follows.

1. To entrance of rain water into well.

2. To the beneficial transformation of harmful organic matter into the harmless ammonia, through the agency of sand, clay, and other substances, which act on the water in a manner similar to the action on it of a good filter.

3. To some salt of ammonia existing in the strata through which the water rises; or,

4. To the decomposition of nitrates in the pipes of the well. Mr. H. Slater suggests that the agent concerned in this reduction may, in the case of the deep well waters, be the sulphide of iron which is found in the clay.

Ammonia may be converted into nitrates and nitrites by a process of oxidation, or be obtained from these salts by one of reduction. We conclude, then, that the presence of free ammonia in such comparatively large quantities in these deep well waters is due to the reduction of nitrates and nitrites by sulphide of iron, or some kinds of organic matter, or some other agent, such oxidized nitrogen salts having been produced in past ages by the oxidation of organic matter."

The State board of health standard limits the free ammonia to .08 parts per million while the Michigan Standard is .05 parts per million and if we attempt to apply these standards we find that of the wells investigated only Dubuque, McGregor No. 2, and the two Manchester will meet the requirement of the two standards and Sabula will meet, in addition to those named, the state limit for free ammonia.

The amount of albuminoid ammonia in the waters will however meet the most exacting requirements. The only exception is that of the Newton sample and this should be investigated again before any definite conclusions are drawn regarding the amount of albuminoid ammonia. If we except this sample it is seen that the results vary from .068 parts per million to a trace.

*Sanitary examinations of water, air and food. Second Ed. p. 92.

Wanklyn classifies waters according to the amount of albuminoid ammonia present as follows:

.05 parts per million. Great purity.
.10 parts per million. Organically safe.
Greater than 10 parts per million. More or less impure.

The small amount of albuminoid ammonia present in the deep well waters places them in the class which is regarded by Wanklyn as characterized as being of great purity. This fact that as far as organic contamination is concerned, the deep well waters are pure waters and this consideration aids in the interpretation of the results obtained for free ammonia as Wankyln considers the presence ot free ammonia as follows:

"If a water yield .000 parts of albuminoid ammonia per million, it may be passed as organically pure, despite of much free ammonia and chlorides; and if indeed the amount of albuminoid ammonia amount to .02, or to less than .05 parts per million, the water belongs to the class of very pure water."

The State Standard is .15 parts of albuminoid ammonia per million which is larger than the amount of albuminoid ammonia in all of the samples except that of Newton. The Michigan standard being the same as that of Iowa.

The presence of chlorine in the form of chlorides naturally does not indicate contamination and the standard of the state board of health of 8 parts per million is of no value for the deep well waters, where the sodium chloride is very high in many samples of water. In the sample of water from McGregor well No. 1 it is seen that chlorine is present to the extent of 967.9 parts per million, and this substance varies from this large amount to a trace in the water from the Dubuque well. When it is considered that the deep well waters contain large quantities of dissolved salts they naturally are associated with the water from mineral springs,* as for example the spring Ems contains 487 parts, Spa 35.5 parts, Carlsbad 630, and Wiesbaden 4687 parts of chlorine per million.

*Smith. Foods. p. 310.

The standards as given by Mason† for chlorine are as follows:

Rain	8.22
Upland surface	11.3
Deep well	51.1
Spring	24.9

Wanklyn considers 140 as possibly suspicious.
Frankland considers the permissible limit as 50.
Leed's standard for American rivers, 3 to 10.
Ordinary sewage, about 110 to 160.
Human urine (average of 24 samples), 5872.

It will be noticed that the standard for deep wells, 51.1 parts per million cannot be applied to the deep well waters of this section, and any standard is of little value as far as it relates to the chlorine that is present in the water, however useful the standard for this substance may be for shallow wells.

The solids on evaporation in the examination of shallow wells is a determination of great value, although the loss on ignition has lost much of its supposed value. In connection with the examination of deep well water, however, its chief value may be said to serve simply as a guide to the total substances present in the water, the nature of which can only be determined by a mineral analysis. The various standards which have been proposed for the solids on evaporation cannot be applied to the deep well water or to the mineral waters. For example the standards which have been selected by Mason,* are as follows.

Rain water	29.5
Upland surface	96.7
Deep well	432.8
Spring	282.0
To be condemned	1000.
American rivers	150. to 200.
Wanklyn regards as permissible	575.

Many of the deep well waters will come within the limits for solids as a few of the solids contained less than 600 parts per million. On the other hand many of the results show that the solids are in excess of 1,000 parts per

†Water Supply. p. 374.
*Water Supply. p. 368.

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million. The solids are composed largely of common substances such as sodium chloride, sodium sulphate and magnesium sulphate. The mineral analyses of many of the samples have been published recently and it is unnecessary to give consideration to this matter here.†

The amount of solids in the deep well waters has had a tendency to cause them to be looked upon with suspicion. When the solids on evaporation in the deep well waters are compared with those of some of the noted mineral springs * as for example.

	Solids on evaporation in parts per million.
Pfaffers	252
Toplitz	295
Spa	563
Teplitz	626
Ems	2,781
Carlsbad	5,455
Wiesbaden	8,262
Seidlitz	16,406
Saidschutz	23,285
Pullna	32,771

It is readily seen that while none of the samples have solids as high as the springs having large amounts of mineral substances yet they will compare favorably with many given in the above table. Many of the samples of water have been tested for lithium with the spectroscope and the results obtained showed that this substance was present in all of the samples that have been tested.

The deep well waters may be said to be characterized by the fact that they contain only traces of nitrogen as nitrites and nitrates. In the Centerville sample the nitrogen as nitrates was caused by the sample standing for some time and as a result the free ammonia was oxidized by the nitrousfying process to nitrous acid. This feature of the deep well waters in which the free ammonia is changed to nitrites and nitrates has been observed in many samples of water and it is hoped that the changes can be investigated in the near future. The oxygen consumed as has

†Iowa Geological Survey. Vol. 6. Artesian Well Waters.

*Smith. Foods. p. 310.

been previously stated is a process which is in a very unsatisfactory state at present. In England we find the modification of the Miller-Tidy method used at present. This method as modified by the Society of Public Analysts we have designated as the English process. The Kubel process and its modifications we find used in this country and in Europe under its proper name and with slight changes under other terms, such as "boiling method." The time of boiling may vary from five to thirty minutes while the time recommended by the American Association is ten minutes. The objection which has been made against the Kubel method is that at the boiling temperature the permanganate acts upon the chlorides present in the water and for this reason many prefer the English method where the temperature of the reaction is 80 degrees Fahrenheit. The object in making the tests at fifteen minutes and four hours is that the fifteen minute test indicates the amount of organic matter readily putrefying and rapidly decomposing permanganate with acid. Angus Smith classed this as organic matter readily decomposed and probably ready to become putrid. The fifteen minute test also includes in the result the action of any nitrites, ferrous iron or hydrogen sulphide which may be present.

The object of the four hour test is supposed to indicate the organic matter capable of putrefying although slow to be decomposed. The total result includes the readily decomposed matter in the fifteen minute test which must be subtracted from the total if the amount of oxygen necessary for the organic matter which is slow to be decomposed is desired. The three minute test is also of value in many determinations as well as the association method. The association method giving results which indicate the total organic matter present is much better than the four hour test in many investigations, although care must be taken regarding the presence of large quantities of chlorine.

Tidy's classification of waters based upon the oxygen absorption is as follows:

Class I. Waters of Great Organic Purity. All waters in which the oxygen absorbed does not exceed .5 parts per million.

Class II. Waters of Medium Purity. Waters in which the oxygen absorbed ranges from .5 to 1.5 parts per million.

Class III. Waters of Doubtful Purity. Waters in which the oxygen absorbed ranges from 1.5 to 2.2 parts per million.

Class IV. Impure Waters. Waters in which the oxygen absorbed exceeds 2.2 parts per million.

The Michigan standard is that water should not require over 2.2 parts of oxygen per million.

It is of interest to note that some of the deep well waters come within the first class of waters according to Tidy's classification and the larger number within the Michigan standard. The application of any standard to the sanitary analysis of the deep well waters is unsatisfactory and misleading in many ways. The most important results, that of albuminoid ammonia and nitrogen as nitrites and nitrates show conclusively that the waters are not contaminated in any manner. The oxygen absorption is valuable in many respects, but the other results vary to such a degree that no standard can be selected which could be applied to the deep well waters as can be done for the waters from shallow wells.

THE CHEMICAL COMPOSITION OF SEWAGE OF THE IOWA STATE COLLEGE SEWAGE PLANT.

BY J. B. WEEMS, J. C. BROWN AND E. C. MYERS.

The sewage plant of the college was constructed in 1898 from the designs and under the supervision of Prof. A. Marston, the college engineer. The plans and a short description of the work of the plant have been recently published* and only the chemical investigations will be considered in this paper.

*The Iowa State College Sewage Disposal Plant and Investigations. Marston, Weems and Pammel. Proceedings Iowa Engineering Society, 1900.