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Madison Well Waters.

The following Honor Thesis was read at Assembly Hall, Friday morning, by MAGNUS SWENSON, of Janesville, a member of the State University Senior class—metallurgical course:

There is probably no branch of sanitary science, of so great importance as the determination of the quality of water used for domestic purposes, and it is certainly very strange that it receives so little attention. As affecting the public health, it is a matter of the greatest moment, and the people cannot afford to ignore this fact as long as we have the means of determining foul and poisonous waters, and are able to replace them by what are good and wholesome.

That water contaminated with refuse matter or sewage is not only highly poisonous, but one of the most active breeders of death and disease, is no longer disputed. In nearly every report of sanitary committees we find the most positive evidence of its dangerous nature. Many examples may be quoted, showing to what an alarming degree foul water may be

THE CAUSE OF EPIDEMICS,

and how virulent certain kinds of sewage may become even in an extremely dilute condition. "It must be remembered that the poison, however trifling, is taken daily, and that, although in robust health we may not suffer from it, it may be sufficient to make itself felt when prostrated by sickness, and our resistance to such influence becomes proportionally lessened."

During the past term I have been engaged in analyzing some of the Madison well waters. For several reasons my work has been somewhat limited, and I have only been able to analyze 52 waters, taken from different parts of the city. Although this small number of analyses may not represent a fair average of the condition of the city waters, they do show that a large portion, I may say a large majority, of the well waters are wholly unfit for domestic use, many of them being better fitted for fertilizers than for human consumption; and instead of attributing many of your deaths and diseases to "the mysterious dispensations of Providence," they may, less irreverently and more truthfully, be referred to the drinking of bad water.

That many of the well waters are bad cannot be wondered at.

A WELL AND A VAULT

cannot exist side by side, with only from 10 to 20 feet of porous earth between them, without having their contents mix sooner or later. The soil cannot take up an indefinite amount of sewage matter. In time it becomes saturated, and the sewage will mingle with your drinking water. There are numerous places where wells have existed for over twenty years, all but surrounded by vaults and cesspools, and to facilitate the mixing, the soil immediately around the well has been treated to daily doses of wash water and slops, and yet people who use the water would wonder why their children were sick, and looked astonished when I told them that their water was

WHOLLY UNFIT TO DRINK.

Why! they would say, the well is 60 to 70 feet deep, and nothing can get into it at such a depth. Sewage does not act differently from any other liquid. It does not go the round-about way of sinking straight down, and coming up through the bottom of the well, but seeks the most direct and easiest outlet, and leaks in through the sides. Generally speaking, the deeper the well, the greater is the surface exposed to the sewage-saturated soil, and the greater will be the inflow of sewage. In some cases the inflow of sewage is so great as to give to the water a decidedly bad odor, but even that does not seem to frighten some people, who believe, that instead of a reservoir of filth, they are the fortunate owners of a mineral well, declaring that on several occasions they have detected the smell of sulphur. If your water has

A SMELL OF ANY KIND,

either when cold or by boiling, don't drink it. The odor does not come from sulphur, but from some decaying organic matter, and that is anything but wholesome.

In order to ascertain the quality of a water, I have made the following determinations: Its deoxidizing power expressed in C. C. of a centi-normal solution of $\mathrm{K_2\,Thu_2\,O_8}$ deoxidized by one litre of the water. The amounts of free ammonia, albuminoid ammonia, chlorine and nitrous acid, all expressed in m. grains per litre, or parts in 1 million.

When $\mathrm{K_2\,Thu_2\,O_8}$ is added to water containing oxidizable matter, and some free $\mathrm{H_2\,SO_4}$, the $\mathrm{K_2\,Thu_2\,O_8}$ is decomposed, and the oxygen liberated will be taken up by the oxidizable substances. Therefore the amount of $\mathrm{K_2\,Thu_2\,O_8}$ decomposed will measure the amount of matter capable of being oxidized in the water. All kinds of organic matter however, are not equally affected by the $\mathrm{K_2\,Thu_2\,O_8}$. One may be very readily oxidized, while another is scarcely acted upon. Hence, if a water has a low deoxidizing power, it does not necessarily prove it to be a good water. If however, it has a high deoxidizing power, it does prove the presence of a correspondingly large amount of oxidizable organic matter, and it also furnishes a clue as to the kind, for the more readily it is oxidized,

*THE MORE DANGEROUS IS ITS NATURE

supposed to be. Some very eminent chemists use this test instead of the ammonia process. I have used them both, and as may be seen from the table of analyses there is a general agreement, although some variations will be noticed. Free ammonia, when found in well water, indicates sewage or surface drainage, both of which are highly objectionable. All kinds of nitrogenous organic matter give off free ammonia when undergoing decay. This is especially true of excrementitious matter, part of which decomposes into carbonate of ammonia, and if a well water contains free ammonia to any considerable extent, it is, to say the least, highly suspicious. The albuminoid ammonia represents the nitrogenous organic matter which has been converted into ammonia by boiling the water with a strong solution of $\mathrm{K_2\,Thu_2\,O_8}$, and caustic potassa. The nitrogenous matter is changed into free ammonia, in which form it is more readily measured. Both this and the free ammonia were determined by the delicate method of nesslerizing. Pure spring or artesian well water is free from organic nitrogen, and consequently no albuminoid ammonia will be found in analyzing such waters. The amount of chlorine is estimated to show the amount of common salt present in the water.

PURE NATURAL WATERS

contain but little more than a trace of salt, while sewage, kitchen-slops and excrementitious matter of all kinds, are highly charged with it.

Whenever therefore, a large amount of sewage is found in a water, a correspondingly large amount of salt is almost invariably present. This association of common salt and sewage is so constant, as to be almost without an exception. The important conclusions which may be derived by knowing the amount of common salt may be inferred from the following remark by Dr. ANGUS SMITH in his report to the Royal Commissioners of the Water Supply of London: "If the amount of chlorine in water from any district is pretty well known, and a specimen of that water should indicate more chlorides than usual, you may conclude with almost certainty that it is from sewage."

Nitrites have been determined as nitrous acid with a solution of iodide of potassium and starch. When this is added to a water containing nitrites, and a little free $\mathrm{H_2\,SO_4}$, iodide of starch is formed which is of a deep blue color, which increases in depth with the amount of nitrites. The presence of nitrites in well water indicates fresh sewage—nitrogenous organic matter so fresh as to be only partly oxidized. The presence of such matter even in but very small quantities is enough to make us regard the quality of a water as decidedly doubtful. Dr. WAUKLYN says that if the color is at all deep, the water can hardly be fit to drink. More than 25 per cent. of all the waters that I have examined contain more than 5. m. g. pr litre of nitrous acid, a quantity sufficient to produce almost a black color.

For the sake of showing more clearly the

CONDITION OF THE WATERS ANALYZED,

I have divided them into three groups—good, suspicious and bad. The group of good waters includes all those whose deoxidizing power does not exceed 45 c. c. of $\mathrm{K_2\,Thu_2\,O_8}$ pr litre. They must be free from ammonia; the albuminoid ammonia does not exceed .1 m. g. pr litre. They must be free from nitrites and contain no abnormal amount of chlorine. In the second group, or suspicious waters, the deoxidizing power must not exceed 60 c. c. $\mathrm{K_2\,Thu_2\,O_8}$; the sum of the free and albuminoid ammonia does not exceed 2 m. g. pr litre. The nitrous acid must not exceed a trace, but an abnormal amount of chlorine is nearly always present. All the rest are classed as bad waters. This classification is somewhat arbitrary, for the quality of a water does not depend so much on the quantity as on the nature of the impurities. The limits which I have taken, however, are beyond those which have been adopted by Drs. TIDY and WAUKLYN, of London, two of the most eminent water analysts, so that a water which is classed as suspicious is more apt to be bad than good.

Of the 52 waters,

ONLY THREE FULFILL THE CONDITIONS

of a good water, ten are suspicious, and thirty-nine are bad. Nineteen of these thirty-nine are absolutely filthy, and could undoubtedly be put to good use on a farm. Four of the suspicious waters are, however, free from sewage, and they may be made good by either filtering the water, or cleansing the well. Forty five out of the fifty-two waters are more or less contaminated with sewage. This is anything but pleasant to realize for people who are obliged to drink the water. In more extended analyses, the ratio of bad water to good would probably be diminished, for many of the waters analyzed are from some of the unhealthiest parts of the city, where I do not think a good water can be found. Several qualitative examinations of waters between State street and Fourth Lake, however, made during the last two weeks, all

SHOW THE PRESENCE OF SEWAGE,

and it appears as if the contamination is more universal than I at first supposed. As far as I am able to judge by the small number of analyses, those parts of the city where the water is universally bad are the regions where typhoid and scarlet fever and diphtheria have prevailed. It would, indeed, be an interesting question and one of great value to the public health, to ascertain, by a larger number of analyses, the intimacy of this relation of bad water and disease. Unfortunately, however, people look unfavorably upon such an undertaking, and will not aid in what they consider unnecessary. They have fallen into a dangerous feeling of safety, and not until it terminates into some frightful epidemic, will people fully realize the danger.

*"It has often been asked,

CAN NOTHING BE DONE TO MAKE BAD WATER GOOD?

This is possible, as before stated, with water free from sewage, but no process has yet been devised for cleansing water once contaminated with sewage, so as to make it fit for drinking. It may be suggested that filtering be resorted to, or the sewage be disinfected, as some are pleased to call certain processes, but the English Commissioners of the water-supply of *London* say that, as applied to sewage, disinfectants do not disinfect, and filter-beds do not filter. Both attempts have been costly failures." The soil possesses very strong disinfectant properties, but when refuse matter of all kinds are continually added to it, year after year, the soil becomes saturated, and the sewage finds its way into the wells in an almost unchanged condition.

CISTERN WATER,

even, if very bad, may be made good by filtering through a charcoal filter. The impurities in such water are largely in suspension, and are mostly organic matter and dust from the roof, along with considerable amounts of free ammonia, derived from the atmosphere. Analysis No. 25 is that of a cistern water taken directly from the cistern, and, as will be seen from the analysis, is a very bad water. Analysis No. 9 is that of the same water after being filtered through a Kedzie's charcoal filter used continually without renewal for two years. By this process, 92 per cent. of the impurities were removed, and it is now a good water. The rather large amount of free ammonia does no harm, as it indicates, nothing but its own presence, as it is all or nearly all derived from the atmosphere as free ammonia; while, as before stated, the presence of ammonia in well water indicates the presence of excrementitious matter, especially urine.

TO CLEANSE A WELL,

into which sewage is continually flowing, is of course useless. It may make the water better for a time, but soon it will contain the usual amount of sewage. Analysis No. 21 in the table is that of a very bad water, being very much contaminated with sewage. Another sample, taken from the same well five days after it was pumped dry and thoroughly cleansed, was analyzed, and the result—No. 51 in the table—shows that already it contained half the usual amount of impurities. If the soil is once saturated, it can never again be relied upon with safety, for the filtration of water for drinking.

I have also found that the amount of contamination depends to a great extent on

ATMOSPHERIC CHANGES.

During a dry season the soil becomes more and more saturated with sewage; for, as there is not moisture enough present to create a rapid current towards the well, the sewage becomes more and more concentrated, until finally a heavy rain falls, and the water percolating through the porous earth into the well will carry with it a large amount of the sewage. To prove that this is the case, I have made three analyses of two well waters at three different times. The first analysis was made two days after the heavy rain on April 20th, and I found the water to contain a very large amount of fresh sewage. The second analysis was made after two weeks of warm, dry weather, and the water contained about half the organic matter previously found, and the third analysis, made two days after the heavy rain on May 22d, showed even a greater contamination than the first. It thus appears that a water may at times give no very bad indications, and yet may in a few days become

A SOURCE OF GREAT DANGER.

It would be very desirable if some figures could be obtained by which the mortality of this and other cities could be compared, but the death rate is either not known or not made public. As far as I can learn, however, it is considerably above the average, and the diseases most prevalent in the city are those which are known to be propagated by bad water. Typhoid and other fevers are very frequent, and I have been informed by good authority that the city

HAS NOT BEEN FREE FROM SCARLET FEVER

for nearly two years. This does not show well for a city advertised abroad as a health resort. The Capital City should not be behind her neighbors in investigating a matter of so great importance, and if found necessary, to render harmless his secret enemy, of the public health and not wait to be convinced of its presence by a further increase of your already large mortality.

TABLE OF ANALYSES.

Number of Analysis.	C. C. of potassium permanganate deoxodized by one litre	M. G. of free $N.\,H_3$ in one litre.	M. G. of albuminoid $N\,H_3$ in one litre.	M. G. of chlorine in one litre.	M. G. of $H\,N\,O_3$ in one litre.	Quality.
1....	29.0	trace	.180	......	none	Suspicious.
2....	73.5	.05	.040	......	trace	Bad.
3....	290.0	2.84	.224	104.0	4.60	Very bad.
4....	165.0	.115	.080	188.0	2.00	Very bad.
5....	45.0	none	.120	22.0	none	Suspicious.
6....	12.0	none	none	7.8	none	Very good.
7....	21.0	none	.080	65.0	none	Suspicious.
8....	72.0	.056	.212	none	none	Very bad.*
9....	24.0	.046	.065	none	none	Good *
10....	47.0	.042	.040	33.0	none	Suspicious.
11....	78.5	.050	[illegible]	[illegible]	none	Very bad.
12....	27.5	.010	.048	132.0	none	Suspicious.
13....	73.0	none	.034	180.0	1.90	Very bad.
14....	40.5	none	.04	24.0	none	Good.
15....	48.0	none	.127	170.0	none	Very bad.
16....	35.5	.085	.118	30.0	none	Suspicious.
17....	59.0	.440	.285	10.0	none	Very bad.
18....	55.0	.320	.201	80.0	none	Very bad.
19....	84.0	.080	.090	72.0	.65	Very bad.
20....	32.5	.720	.065	205.0	none	Very bad.
21....	745.0	.840	1.8-0	90.0	2.05	Very bad.
22....	180.5	.440	.271	496.0	none	Very bad.
23....	85.5	.090	.282	364.0	none	Very bad.
24....	110.5	1.015	[illegible]	198.0	none	Very bad.
25....	219.0	.465	.700	154.0	9.10	Very bad.
26....	118.5	.180	.180	205.0	none	Very bad.
27....	165.0	.385	.250	188.0	trace	Very bad.
28....	120.0	.032	.270	198.0	none	Very bad.
29....	60.0	.140	1.040	57.0	non	Very bad.
30....	180.5	.090	.386	85.0	.15	Very bad.
31....	277.5	.210	.300	48.0	.37	Very bad.
32....	461.0	.840	1.340	180.0	.82	Very bad.
33....	74.0	.080	.090	88.0	none	Very bad.
34....	86.0	.086	.075	28.0	none	Very bad.
35....	127.0	.840	1.150	none	none	Very bad.*
36....	96.0	.080	.2-6	288.0	.10	Very bad.
37....	57.0	.080	.300	22.0	.90	Very bad.
38....	94.0	.575	.480	108.0	.10	Very bad.
39....	22.5	none	.050	47.0	none	Suspicious.
40....	47.0	.270	.790	118.0	trace	Very bad.
41....	44.0	.090	.170	14.0	.08	Very bad.
42....	60.0	.075	.440	148.0	trace	Very bad.
43....	56.0	none	.125	24.5	none	Suspicious.
44....	90.0	.105	.090	73.0	trace	Suspicious.
45....	58.0	none	.030	28.0	none	Suspicious.
46....	40.0	none	.340	11.5	none	Bad.
47....	78.0	.380	.380	6.5	none	Bad.†
48....	74.0	.085	.200	115.5	.15	Very bad.
49....	122.0	.080	.280	17.0	none	Very bad.
50....	66.0	.800	[illegible]	182.0	trace	Very bad.
51....	845.0	.080	.280	122.0	1.37	Very bad.
52....	......	.08	1.104	68.4	trace	Very bad.

*Cistern water. †Fourth Lake.

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SEED CORN.—I have made a great many experiments with corn within the last fifteen years. I had fourteen different kinds, and this year I got some of the largest ears I ever raised. I always select my seed corn in the fall at husking time, and in the spring I sort them over again. Last spring I took no ears that were less than twelve inches long; then I took off three inches at the tip end and two inches at the butt end, and from these central grains I got ears fifteen inches long and from fourteen to sixteen rows. Several years ago I selected ears from stalks that had two ears but the result was not near so satisfactory as from planting only central grains. My opinion is, if farmers would be a little more careful in selecting their seed corn they could raise from five to ten bushels more per acre than they do when they pick it out of the crib in the spring.

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—GARFIELD is of Welsh and ARTHUR of Irish descent.

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*Pop. Science Monthly, vol. 14, p. 55.