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Henry Albert

THE POLLUTION OF UNDERGROUND WATERS WITH SEWAGE THROUGH FISSURES IN ROCKS.

BY HENRY ALBERT.

The possibility of pollution of underground waters through fissures in rocks has long been a well established fact. The actual demonstration of such as the source of cases or epidemics of disease in Iowa has until recently not been proved. It is with the idea of reporting an epidemic of typhoid fever due to pollution of this kind and of calling attention to the need of a sanitary water survey in Iowa, that I present this paper.

The more superficial rocks of the state present many joints or fissures, through which pollution with sewage material may pass. Many of the springs of the state which issue from such fissures, have their source of water supply from the superficial layers of soil not far away which means that such water has not been subject to very much filtration or in case the water has entered sink-holes which are especially common in the northeastern corner of the state, has probably not been filtered at all.

THE CEDAR FALLS EPIDEMIC OF TYPHOID FEVER.

During the fall of 1911 there occurred at Cedar Falls, an epidemic of typhoid fever during which about 100 persons were affected, and about 20 died. The water supply of Cedar Falls previous to the time of the epidemic was from a spring in the valley of Dry Run, a small intermittent tributary of Cedar river. It comes from a fissure in the Devonian lime-stone. That this water was the source of infection was shown by both the epidemiological data and laboratory examinations indicating contamination of the water with sewage material. That the water comes in part at least from surface soil is shown by the fact that it becomes turbid after a heavy rain and high river floods. It was at first believed that the water issuing from the spring was contaminated, and that the contamination had occurred through fissures in rocks. Many repeated tests with fluorescein have however all been negative. Prof.

Arey informed me recently that in case of high water, although the city water was turbid, the water from the spring remained clear. He believes that the contamination probably occurred entirely while the water was being conducted from the spring to the collecting system at the pumping station through an old wooden conduit buried in the ground subject to overflow from the river. The fact, however, that the number of bacteria in the water directly from the spring varied from 40 to 480 per cubic centimeter and that the water in many of the neighboring deep wells with pipes extending into the limestone of the surrounding country becomes turbid in times of high water, would indicate that there is some contamination of the water through the fissures in the rocks with material of the neighboring stream or surface soil.

It is worthy of note that the public generally regards all spring water as pure. The people of Cedar Falls were astounded when it was announced that their water supply was the source of the infection. When in 1904, after Waterloo had experienced an epidemic of typhoid fever, that city was casting about for a new water supply, many of the citizens suggested the construction of an aqueduct to the spring at Cedar Falls.

THE FORT DODGE EPIDEMIC.

An epidemic of typhoid fever occurred at Fort Dodge, during the summer and fall of 1912. About 100 persons were affected by the disease of whom four died.

The water supply of Fort Dodge comes principally from the deep wells. They also take the water from pipes beneath the river. The source of infection was apparently from both the pipes beneath the river and from one of the deep wells. The feature of interest is in connection with the latter. This well (Well No. 1) which was the first of the three wells as also the deep stone—being 1,827½ feet deep and extending to the Jordan sandstone, was started at the bottom of a large shaft which was constructed several years previously for the purpose of supplying the city with water. This shaft which measures 10x10 feet across extends down for 90 feet. From the west side of the lower end of this shaft, a tunnel, 9 feet in diameter, was extended under the Des Moines river. This tunnel was driven in sandstone, so required but few timbers for support, whereas the shaft has a wooden casing for almost its entire extent. The shaft extends successively from above downward through the following layers of earth:

Alluvial gravely soil and clay.31 ft.
Limestone ..... 6 ft.
Shale, blue .....27 ft.
Limestone ..... 6 ft.
Sandstone.....42 ft. (tunnel in this formation.)

There are only about 20 feet of gravel, alluvial soil and clay from the bottom of the river to the first layer of limestone. Through this the water from the river and surrounding soil will probably pass quite readily and without efficient filtration. It then comes to a layer of limestone which is known to contain many fissures, through which water may readily enter the shaft. Beneath the limestone is a layer of blue shale, 27 feet in thickness. This is relatively impermeable to water, hence tends to keep the water from passing directly downward and so hastens the passage of water laterally along the limestone fissures—in the direction of drainage—namely, toward the shaft. Previous to the construction of the tunnel the seepage into the shaft was at the rate of about 55 gallons per minute. This was increased to 80 gallons per minute by the construction of the tunnel. This would seem to indicate that the water which enters the shaft is of recent surface origin. That the water must have come principally through such fissures in the rocks is indicated by the fact that when the shaft was constructed, but little water appeared until after the limestone layer with its fissures had been entered.

That the water which comes from the shaft is polluted with sewage material has been shown repeatedly by chemical and bacteriological examinations. When the first artesian well was drilled (Well No. 1) it was started from the bottom of the above mentioned shaft. The casing of this well extends through the shaft and projects at the top several feet above the level of the water in the shaft. The water flowing from the artesian well fell into the shaft which became filled with water to the top of the discharge pipe. In this manner the water from the artesian well and the seepage water from the shaft and tunnel were mixed. Soon after the completion of this artesian well, a sample of this water was sent to us for examination. We expected to find either no bacteria or only a very few. We found, however, that the bacterial count went up to 42 per cubic centimeter with 2 colonies of colon bacilli. Chemical examination likewise showed evidence of contamination with sewage material. The reason for this was not explained until after a personal inspection and subsequent examinations showed that the contamination occurred in the large shaft with water from the shaft and

tunnel. The water taken directly from the well did not show any evidence of pollution. We believe that the water of the tunnel and shaft comes largely quite directly from the river through fissures in the rocks and hence is not properly filtered.

CONCLUSION.

We believe that the pollution of water through fissures in rocks occurs more frequently than is generally thought to be the case. But whether from that source or some other, pollution of public water supplies in Iowa is of common occurrence. With polluted water supplies, the question of epidemics of typhoid fever is, of course, a possibility at any time. There is great need for a thorough sanitary water survey of the state. The State Geological Survey has accomplished a most meritorious work in its study of underground waters. The report will be of great service to sanitarians, but there is now an urgent need for a survey, the prime purpose of which will be to determine whether or not a given water supply may be the source of disease.

I desire to acknowledge my obligations for most of the data upon which this paper was based, to A. L. Grover, of our laboratory, who made the epidemiological investigation of the outbreak of typhoid fever at Cedar Falls; to A. M. Alden, also of our laboratory, who made a similar investigation of the epidemic of typhoid fever at Fort Dodge and to M. F. Arey of Cedar Falls; W. H. Norton of Mt. Vernon and G. F. Kay of Iowa City for geological data.