Utah's Water Supply

BY F. E. CLARK

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The average individual judges of the quality of a drinking water by means of his special senses of sight, smell and taste. Water that is turbid or emits a disagreeable odor is unreservedly condemned, while clear sparkling' water free from odor is just as unqualifiedly pronounced pure. Those of us who are familiar with the history of typhoid epidemics and have had opportunity to examine drinking water by means of special methods know how fallacious such a crude judgment is. Water that is clear and sparkling may contain the germs of typhoid fever or may be polluted with sewage which, in the course of decomposition, gave rise to carbonic acid. It takes many billions of bacteria to render a glass of water perceptibly turbid and it requires considerable fresh sewage to impart to it a fecal odor. On the other hand a turbid water, although objectionable from an aesthetic point of view, may be entirely wholesome and a disagreeable odor may be due to inoffensive vegetable compounds or harmless algae. Being thus unable to form a ready judgment of the quality of a drinking water we were obliged to seek thé aid of the chemist, who, it was supposed, could readily detect by means of chemical analysis the injurious substances in the water under suspicion. However, it soon became evident that the findings of the chemist were purely relative and would have to be properly interpreted before they could be of any value. The object of a chemical analysis of water is to discover whether or not pollution with objectionable organic impurities has taken place. By "objectionable organic impurities" we understand those which are from human or animal sources and are capable of conveying the germs of disease. In other words, we look for fecal contamination, inasmuch as the germs of typhoid fever, cholera, dysentery and other intestinal disorders are excreted with the feces, and together with the feces gain access to the water. In minute quantities organic matter, even if derived from sewage, is not in itself injurious; it is only that such matter may become the carrier of disease germs that it becomes a matter for serious consideration. Therefore organic matter derived from plants or vegetables, removed from the possibility of infection with disease producing bacteria has no significance from a sanitary standpoint, and its presence in drinking water in no way renders it unwholesome. It is evident then that the aim of the chemist is to discover, first, the presence of organic matter which would indicate pollution, and second, to determine the source of such organic matetr. Dead organic matter in water, as elsewhere, is not in a state of stability. Through the agency of certain bacteria, in the presence of oxygen, it continuously undergoes certain changes, becoming resolved into simpler inorganic compounds. The nitrogenous substances are converted into ammonia and the latter into nitrous and finally nitric acid, the two acids combining with bases usually present to form nitrites and nitrates respectively. This process is a beneficial one, for by its means purification of polluted water is brought about and the decaying organic matter is converted into useful plant food. These changes are going on continuously so long as there is a supply of dead organic matter and the necessary bacteria are present. It would follow then that the organic matter in a water would be made up of; that portion that has not as yet undergone disintegration (not yet broken up)—that portion that has passed the stage of albuminoid ammonia and finally all the intermediary products of that portion that is undergoing or has undergone disintegration. The quantitative relation of these products of oxidation to each other as well as to the unoxidized nitrogenous matter will depend on the original amount of the organic matter and the rapidity with which oxidation has taken place. For example, take a sample of water; if the chemist after analysis finds that it contains relatively large amounts of albuminoid and free ammonia together with nitrates and nitrates, the indications would be that such water contains a large amount of organic matter in a state of incomplete oxidation; in other words, the contamination is recent. On the other hand the presence of nitrates (the end products of disintegration) in the absence of nitrites with only small amounts of free and albuminoid ammonia, would indicate complete oxidation or a previous pollution. There are a few reasons why the data secured by a chemical analysis are inaccurate: (1)—in ground water excessive free ammonia may be the result of the oxidizing action of iron or other metals on the nitrates present, while in surface waters it may be produced by the action of a fungus. (2)—the nitrites found in deep well-water may be the result of the reduction of nitrates normally present in the soil and consequently is no index to organic pollution. The chemist in other words may detect organic pollution in a water, but he is unable to state definitely whether such pollution is of animal or vegetable origin. Here let me state that a water polluted with organic matter of a vegetable origin, may not be the best kind of water to drink, but may be nevertheless harmless. (3)—then the last and most serious objection is that water may be entirely free of organic pollution and yet contain the germs of disease. Numerous instances have been cited, showing that water pronounced on chemical evidence to be above suspicion has been proved to have caused serious epidemics of typhoid fever and dysentery. This leads us to the consideration of the most important phase of water examination that of bacteriology. By means of Koch's plate method of isolation we are able to detect the specific cause of disease. I will not attempt to discuss the details of the bacteriological examination of water, suffice it to say that the value of the results obtained depends upon the experience and technique of the sanitarian; he has many obstacles to overcome, but that he has been successful and is becoming more and more proficient is shown by an ever decreasing death rate and a diminishing frequency of epidemics. I hope that I have succeeded in making clear to you what is meant by the terms, "Pure and Impure Drinking Water." If I have you will the more readily appreciate the facts to be submitted concerning "Utah's Water Supply." Because of the many differences peculiar to various sections of the state, differences in altitude and climate, differences in rain-fall, differences in geological formations, differences in location as to comparative proximity to mountains, etc.; differences in soil and drainage, and differences in the habits and customs of people, it would be manifestly impossible to enter into more than a general discussion of the water question. I will therefore attempt to point out to you in a general way the problems confronting us as a state and will assign to you the task of adaptation. All water from whatever source obtained, comes originally by precipitation from the atmosphere. In many places the rain or snow water is the only source of supply. This is usually collected as it falls upon the roofs of buildings and conveyed by gutters and pipes to cisterns, where it is stored until needed. In all probability rivers and smaller streams supply the larger number of cities and towns in the United States. When the river or stream can be tapped near its source, or before a large number of manufacturing establishments can empty their waste products into its current, or before it receives the sewage of a considerable number of inhabitants living on its banks, the water can generally be considered safe. Among the minor objections to this source of supply are the liability of most streams to become turbid in time of freshet, and the discoloration of the water from dissolved coloring matters if the stream flows through a marshy or peaty region. The organic matter contained in the water of some streams even when pollution by sewage and manufacturing refuse is absolutely excluded, may, however be the cause of disease. For example, certain authorities claim that the water from streams in Nebraska, Wyoming and Utah contain organic matter varying in amount .16 to .28 parts per million, and that the disease known as Mountain Fever is due to this large amount of organic matter in the drinking water. The source of this organic matter seems to be the melted snow which makes up a large portion of the streams. The most serious objection to the use of river water for domestic purposes is the employment of streams as carriers of refuse from manufacturing establishments, or of the sewage of cities and towns. It would be very easy to cite innumerable instances where typhoid fever epidemics are directly traceable to such forms of pollution, but I will take it for granted that you are familiar with such facts; if you are not it is your own fault, for our worthy secretary, Dr. Beatty, is an enthusiast on the subject and has to my knowledge disseminated useful information among you by means of the monthly bulletin. A few years ago it was a generally accepted theory that running water purified itself after flowing a distance of ten or twelve miles, and the comforting and reassuring doctrine is still held by many. The reasons advanced for such a theory were: (1)—That the movement of the water produced an extra surface available for oxidation purposes; (2)—That the volume of water bearing down upon any given area beneath it weakened the vitality of certain bacteria. (3)—That the influence of light (the sun's rays) was inimical to the growth of bacteria. (4)—That the presence of vegetation (algae) has a marked influence in the reduction of organic matter in water. (5)—That by reason of the dilution of polluting substances with large quantities of pure water, the percentage of impurities is lowered and the percentage of oxygenated water is raised. (6)—That by virtue of sedimentation and side-adhesion to the banks of rivers and streams of solids in suspension a large number of bacteria are removed. Hence lake water contains as a rule very few bacteria. (7)—That the process of oxidation will take care of great quantities of impurities. At the present time we can no longer accept this theory of self purification of streams; we believe that, if the inflow of sewage and other refuse is not excessive, running water will regain comparative purity, but as it is impossible to compute the degree of pollution we can never feel confident as to when a stream once polluted, becomes fit to use again. The water from fresh water lakes and ponds is generally to be preferred to river water for domestic use. It is less liable to become turbid from time to time and except in the case of small ponds, the inflow of sewage is not likely to cause fouling of the water to any serious extent. When the supply can be drawn from large lakes, as is done in Chicago and other cities on the great lakes, no purer or better source could be desired. In such cases the intake should be far enough from shore to avoid the possibility of sewage contamination. The water in small lakes and reservoirs sometimes becomes offensive in taste and odor somewhat resembling cucumbers, due to a minute fresh water sponge, the Spongilla Fluviatilis. Another odor described as the pig-pen odor is due to the decay of certain species of algae. We do not know whether or not these algae are in any way prejudicial to health. Here let me state that the purification of water by means of freezing is in no way absolute as was formerly believed. A considerable number of bacteria, infusoria and other organisms remain in the ice and retain their vitality, so that when thawed they rapidly multiply.

We now come to the course of supply of water for most persons not aggregated in large communities, such as cities and towns, springs and wells. Ordinarily spring-water is clear, cool and sparkling with a refreshing taste and uniform temperature and may be recommended for domestic use where attainable. Spring-water usually comes from a source at a great depth below the surface and after it has percolated through thick strata of soil before appearing at the surface of soil it looses most of its organic impurities. However, it may become impregnated with minerals and gaseous substances as well as organic pollution in its passage over the surface, or through the upper strata of soil. Therefore a spring contemplated for municipal use should be tapped as it issues from the ground; it should be analyzed for purity (chemically and bacteriologically) and if found to be pure should be absolutely protected from possible contamination. Well water is derived from those strata of the soil which are the most likely to be contaminated from the products of animal and vegetable decomposition, and the unwholesomeness of the water is universally proportional to the degree of saturation of the soil with the products of decay. Artesian water may be a good water for domestic use, but very often coming from a great depth as it does, it becomes impregnated with iron or other minerals to such an extent as to render it unfit for use. A good water for domestic use should possess the following qualifications:

(1)—It should be colorless, transparent, sufficiently aerated, of uniform temperature throughout the year, and without odor or decided taste.

(2)—The mineral constituents (magnesium and lime salts) should not be present in greater proportion than 4 or 6 parts per 100,000. More than this gives to water that quality known as hardness.

(3)—There should be but little organic matter present, and no living or dead animal or vegetable organisms.

(4)—The water should be free from ammonia and nitrous acid and should contain but very small quantities of nitrites, chlorides and sulphates.

(5)—It should contain less than one milligram of lead per litre.

(6—It should contain no pathogenic bacteria and but few water bacteria.

Now that we know what a good potable water is, let us apply this knowledge to our own conditions and see just how far short of the ideal, the sources of supply in Utah will come. I shall endeavor first to describe existing conditions as accurately as possible; then I shall give you simple tests in order that you may be able to investigate conditions for yourselves, and lastly after you have satisfied yourselves concerning the existence of certain conditions I shall attempt to suggest remedial measures. As the chief source of water supply in the country and in the villages and small towns of Utah is derived from ground-water, it is important that we have a clear understanding as to what is meant by the term ground-water. At a variable depth below the surface of the ground, a stratum of earth or rock is found through which water passes with difficulty, if at all. Above this there is a stratum of water which moves from a higher to a lower level, and which varies in depth at different times according to the amount of precipitation (rain or snow-fall) and according to the level of the nearest body of water toward which it flows. This stratum of water is termed ground-water, and has within the last few years assumed considerable importance from its apparently close relation to the spread of certain of the infectious diseases namely typhoid fever, cholera, dysentery, etc. The direction of horizontal flow of ground-water is always toward the drainage area of the district, usually toward lakes, rivers or the sea. Rains, irrigation or a rise in the river, will cause a rise in the ground-water, while long continued dry weather, or a low stage of the river which drains off the ground-water, causes a fall in the latter. No doubt many or all of you realize these truths concerning ground-waters; at least you have observed the rise in the level of the well at the advent of the irrigation season and its subsequent fall at its close. It may be difficult to convince some of you that there is a direct relationship between the rise and fall of the ground-water and the prevalence of disease. But if you will stop to realize that between the level of the ground-water and the surface, there is a stream of earth more or less moist, due to previous saturation from rain-fall or irrigation, and that in this stratum of soil, the processes of decay and putrefaction are continually going on, you will appreciate how easy it would be for such pollution to work its way into your source of supply (your well). We will say for example that the area upon which a house or town is built is in a moist state from any cause whatsoever and that the processes of decay are active, the ground-water rises, the ground-air becoming charged with carbon dioxide and other products of decomposition, is forced out of the pores of the soil by the rising ground-water, and escapes into the external air, or through cellars and basements into houses, and may there cause disease. The saturation of the soil with water prevents the further development of the bacteria of decay, and this is checked or putrefaction may take place. If now the ground-water sinks to its former level, the processes of decay again become active in the moist stratum, and large quantities of carbon dioxide and other inorganic compounds are produced. If the germs of disease have been introduced into the soil they also multiply, and by gaining access to the well or stream from which the drinking water is obtained, they may cause infection. A great authority has laid down the rule that a soil with a persistently low stage of ground-water, say 5 meters below the ground, is healthy; a persistently high stage of ground-water less than one and one-half meters below the surface, is unhealthy; while a fluctuating level of ground-water, especially if the changes are sudden and violent, is very unhealthy. This would lead us to expect that places where this fluctuation is very great would show a large mortality from such diseases as are attributed to impurities in the soil. In certain localities of India cholera is never entirely absent, Calcutta is one of these places. The rainy season there begins about the first of May and continues until the end of October. During the next six months there is comparatively little rain. The deaths from cholera begin to increase from October and reach their height in April. The annual death rate was 4,013—of these 1,238 died in the rainy season and 2,775, nearly three-fourths, died during the period of dry weather. I might cite several instances in the history of our own state regarding the relationship between the prevalence of typhoid fever and the subsidence of the ground-water level, but will not take the time for I think you are convinced. If you have read the monthly bulletin issued by the State Board of Health, you have observed that typhoid fever, a preventable disease, occurs more frequently than any other disease and that it stands among the first as a cause of death. It has been said by a great authority that the prevalence of typhoid fever in a community is a true index of the sanitary intelligence of that community. If we accept that statement as true where in the scale of human intelligence would we of Utah come? In some sections of our state where conditions are extremely bad, it would be impossible to approach the ideal in a sanitary way, but there is no community however situated that cannot be improved and rendered relatively immune from typhoid fever if ordinary intelligence is displayed. I think that I can positively state that there are no more than five or six communities in the entire state of Utah depending upon surface wells for their source of water supply, that are giving any thought to the protection of that supply from contamination of any sort. Small communities that derive their supply from small streams give no thought to the protection of that stream from pollution; animals have access to the stream at all times and the percentage of organic matter in its waters

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