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THE PRESENT TENDENCIES IN THE BACTERIOLOGICAL EXAMINATION OF WATER

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It is not at all surprising that there should exist a strange misconception of the present status of the examination of water for its bacteriological content among those people whose knowledge of the subject is limited by what they read in the scientific articles of our Sunday supplements.

All of us who are engaged in the study of water supplies and in the laboratory work connected with the water supply industry have very peculiar demands made upon us from time to time. These demands are frequently based upon these misconceptions attained thru warped understanding of the pseudo scientific articles of the newspapers with their drawings of fabulous animals. Not only is there a very flattering misapprehension as to what the loboratory man is able to do with a given sample of water, but he is expected to be able to do these astonishing things while the person who brought the sample waits for his bottle. Presumably he has some other use for it. The fantastic nature of some of the demands made is amusing.

There is a story of one of the early workers in this country to the effect that one day he received a strange looking sample of water from a nearby populous city, accompanied by a letter on an official lettedhead signed by one of the aldermen. The note demanded — and it is not an unusual demand today — that the sample be examined to find out just exactly what bacteria were in the water.

As he was already aware of the amount of work the public thought was involved in the matter and realized that the effort was considered to be very slight, the laboratory man wrote to the mayor of the city. His letter explained that there would be a considerable amount of work involved and asked if the individual who ordered the analysis of the water was responsible and if the city would guarantee payment of the charges. A letter was duly returned by the mayor stating that the cost would be paid. Accordingly a qualified assistant — probably a graduate student — was assigned to the job of isolating the various bacteria in the water and of identifying them as fully as was then possible. Time went on and the assistant was able to identify an imposing number of organisms. After a while a bill for about $1200 was sent in. I do not know whether the bill was ever paid or not. But a big to do was made over the matter and the city officials probably thought that they were very much overcharged. They were, if one considers the value of the work done on the basis of the useful information furnished to the city. But on the basis of time and the materials used, the hours spent in the libraries studying descriptions of organisms, and the actual effort involved, the city was probably charged a most modest rate for competent work. It is a very useful thing to know what you really need in an investigation and why you need it. To decide such matters intelligently, and to use the information obtained is usually more difficult than to get the numerical data. At least it requires more judgment and experience.

Almost every week there come to public water laboratories requests for the examination of water for typhoid organisms, for the identification of all bacterial species present, and demands for the determination of everything organic and inorganic contained in the water sample sent. And there come demands for information of the effect of a particular water on paint, fabrics, metals, animals, bottled beverages of commercial or home production, and on aluminum cooking utensils. There are demands for data on the effect of the constituents of the sample on everything connected with the human body and its functions, beginning with Aaron's sign and going clear thru the alphabet to zymurgy, which is the application of fermentation to the production of beverages.

Some of this data can be given. Much of it could be approximated if there were but one specimen received at the laboratory and the worker had unlimited time to devote to that special sample. But the city, or the state, or the corporation paying for the time used in the necessary investigation would in most cases find the work too expensive for the value. Besides this, too much routine work would be waiting attention in the interval.

The water works industry is understanding more and more what is and what is not useful and usable data. To be sure new methods and new problems are continually coming up to receive study, investigation, and adaptation to the needs of the various plants. Sometimes we get too interested in a single new phase or new process and claim more for it than is justified. But what line of human endeavor or interest is exempt from this charge?

The water works industry is appreciating more and more the comparatively slight value of an occasional analysis, and the much greater and more far-reaching significance of mass data when properly presented and marshalled. We no longer demand the examination of a single specimen of water from a source which had not received an inspection on the ground by a qualified person, and then, if by chance the results are satisfactory, rest content with the findings for periods of years.

We realize that a specimen of water collected at this moment may be essentially different from a sample collected an hour hence, and that it in its turn, may be entirely different from a specimen collected in the morning. This is why we want mass data. We want to have the opportunity to follow changes in the composition of the water and in the type and abundance of bacterial flora. Some of the changes may be highly significant, or they may be at least suggestive.

Slowly an idea of the need for close watchfulness over water supplies is penetrating to the consciousness of the general public. An analysis dated 1884 and couched in archaic terminology, as science considers it today, written out to be filed away among the records in the archives, no longer has the authority that it used to possess. Some towns used to follow the old practice of sending samples one after another to the laboratory for examination so long as the results were bad. Then, when by accident a good speciment was collected and the report received, immediately they would stop having their supply checked up. Today such self deception is less common — but it is not extinct.

And so, when we realize how casings deteriorate, how the tops of wells, even the deep ones, are left in dangerous condition by failure to close the openings at the top, or by the displacement or damage of the protective devices, and we understand how filter plants cease to function properly at the most unexpected times due to causes which may or may not be obvious, we become more than ever appreciative of that providence which seems to look after children, and those who will not look after themselves, and so belong to the other well-known group.

I have said that the need for constant watchfulness is slowly penetrating to the consciousness of the general public. Such an inclination to trust to ancient examinations as has been referred to has long gone by the board in the better conducted, more up-to-date water plants where the persons in charge realize the difficulties and the variable nature of the water supply. In the past the plants where these things have been taken into account have been the larger ones which could afford the services of the most competent, and the best informed men. It is in the small plants, especially those served by wells or supplied with water which requires no treatment, where lack of knowledge of the local situation may be expected to persist for the longest time. In many such places the general idea seems to be that a man who knows how to throw a switch and how to tighten a packing knows enough to operate a water works plant. But such men, with the best intentions in the world, are too frequently making costly errors which entail not only money but perhaps sickness, as well. Health, and safety from fire, as well as satisfaction, are purchaseable. Usually we get what we are willing to pay for, in water supply, as in other commodities of life.

Assuming then that you are willing to grant the necessity of the collection of mass data and its importance in controlling water supplies, there are some points which need to be considered in order that errors may not result from improper presentation. There is danger that in the calculation of averages and in the dependence upon these simpler values, we may submerge the information furnished by the unusual sample. Sometimes it is the unusual sample which opens our eyes to some condition about the supply which we had not suspected, or to which familiarity with a condition had blinded us. The unusual sample may and should set us to wondering and to experimenting to try to find out what the unusual results actually mean. Of course the specimen may have been accidentally contaminated, since even experienced men occasionally contaminate a sample. But it may have been absolutely representative. At any rate we need to know what the situation is, and the sample should be an irritation to us until we feel we know. And when we do know, the results may be far-reaching. They may call for added protection, they may indicate necessary alterations or repairs, they may point out an unsuspected weak spot, — or they may mean nothing at all. But our attention once more will have been directed to a careful inspection and the necessity for reasonably close and reasonably frequent inspection of our sources to determine their adequacy and fitness.

But I have been talking about examinations in general, and not, about the tendencies of the bacteriological examination. In what I shall have to say about that matter, I hope that you will not be given the idea that I am discussing the only kind of an examination which has value. The bacteriological examination is of value as presenting but one of four sides of a complete examination — or perhaps in many cases only one of five aspects. The four principal components of a water examination are 1.) the sanitary survey; 2.) the clinical history; 3.) the chemical analysis and 4.) the bacteriological examination. To this may be added, particularly in the case of surface supplies, 5.) the microscopical examination for algae and other higher aquatic life. In any of these classes a negative report is very much less significant than a positive finding in any other one.

The intermittent character of various types of pollution of waters does not receive the attention which it merits, but the sanitary survey, or the clinical history may force our attention to such possibility. And so also may the findings of the chemical analysis, even in the presence of a fairly passable bacterial examination. Bacteriological work on the other hand tells primarily the condition of the water sample at the time the examination is begun. It does not tell clearly of remote pollution except perhaps in special cases thru the medium of the colon group, neither does it suggest future conditions essentially differing from that of the present. Occasionally it can point out hidden defects, unsuspected because the point of weakness is covered by earth or otherwise rendered inaccessible to the person who makes the sanitary survey. The bacteriological examination can help to point out conditions that have not yet culminated in histories of water borne disease. It can measure the degree of removal of bacteria in the various steps of the natural or artificial purification of waters. It can aid in demonstrating the normal fluctuations in the quality of any particular water. To rely on the bacterial examination for more than these is to invite error.

As in most lines of endeavor we find a tendency to make dogmatic pronouncements regarding bacteriological examinations and their results. This is especially likely to be done by persons of little experience or those whose experience has been limited to a narrow field or a restricted locality. These dogmatic statements have the advantage of being easily remembered, but they may be responsible for actual harm, since instead of reasoning about the results in a special case, the dogmatic statements may be recalled to memory and be applied as truths when, as a matter of fact, they may be untrue under the existing conditions, or what may be almost equally bad, correct only within certain limits or with certain reservations.

Since our early work on the chemical and bacteriological investigation of waters was done in the eastern states, we find in many cases that there has been a tendency to apply standards which may be very satisfactory for Massachusetts and New England to conditions of the Middle West and elsewhere which are in some

Proceedings of the Iowa Academy of Science, Vol. 33 [1926], No. 1, Art. 8

respects essentially different. There is little reason to doubt that in some instances injustice has been done to water supplies, that considerable amounts of public money have been spent unnecessarily, and that unnecessary alarm and undesirable opinions about water supplies have been spread thru communities as a result of the attempt to judge supplies on a basis properly applying to some other localities. The matter of causing communities to distrust or fear their water supplies when as a matter of fact they are safe, is a thing of grave public health importance. How important it is may be recognized when it is remembered that sixty, seventy, or even eighty per cent of private water supplies in the same locality are likely to be found unsatisfactory or definitely unsafe. To throw doubt upon the character of a public water supply almost always drives the citizens back to their private supply, even when it is suspicious in quality, and a very real danger may result. Private wells are nearly always neglected, and they are likely to be in even worse condition than usual when they have been unused for a time as when the people of a community have become accustomed to the greater convenience of city water taken from the tap at any time and on any floor.

But to return once more to the subject under discussion — there are but two or three things which we might expect to learn from a bacteriological examination. These are: the presence or absence of pathogenic bacteria, the presence or absence of bacteria which indicate sewage pollution or the entrance of surface waters, and finally the relative abundance of bacteria of all sorts which will grow at the temperature used and on standard media.

Except in a few instances the pathogenic bacteria are not regularly sought for, at least not as a routine measure. Even in the cases I have in mind, the search for pathogens is more of a "stunt" than anything else, and the reliance of the responsible people is put in the usual examinations to supply the desired information with regard to the safety of the water. The reason for the practice of omitting to search directly for the pathogenic forms is based on the relative value of a negative finding and of a positive one. Failure to find the pathogen, in the light of our present methods, does not give a guarantee that the dangerous organism is absent from the supply. It merely evidences that they were not found. The particular part of the sample used may not have contained the organism sought, or the media or the temperature used for cultivation may not have been quite right. Something may have been wrong with the technique of the operator, or the organism may have been overgrown, or it may have died from some cause or other. There are by far too many possibilities of error to make a negative finding of definite value when searching for the comparatively rare pathogenic organism in the sample. And so positive results are rare, too. The solution of this matter is, as you all know, to select an indicator organism. The ideal indicator organism is one which would exist in water containing the pathogens sought and which would be present in much greater number than the pathogens themselves. It should be easy to detect and identify, characteristic of the material in which the pathogen might be expected to be, and should not be found in material of innocent origin. The indicator which has been used for this purpose most commonly is, of course, the Bacterium coli. We consider that it is quite characteristic of sewage, and we know that it is in such material that the organisms of the most important water borne diseases such as typhoid fevers, and other intestinal disorders are most likely to be encountered. The typhoid organisms are the pathogenic forms which concern us most. Since the Bacterium coli would be very much more abundant in sewage than the typhoid organisms and other highly objectionable ones, we may reasonably feel that if we can keep the Bacterium coli count very low, we have introduced a considerable factor of safety not only against any non-specific diarrheas, but also against specific infections.

In water analysis, as in many other things, we inherit many of our ideas from our predecessors. Evolutionary modification in the light of newer information, or logical selection modifies these ideas to a certain extent, but not nearly so rapidly, nor so completely as one might be inclined to suppose.

The matter of bacterial counts and their interpretation is an inherited thing, even tho bacteriology is a young science and although the whole rational development of the phase discussed is less than fifty years. Bacterial counts were not easily attempted until Koch developed the gelatine plate counting method in the early eighties. Before that time (if we exclude potato slants, plaster blocks and the like) media had been liquids in which the bacteria could move or were at the mercy of currents. Koch's gelatine method more nearly immobilized them, and allowed the growth of colonies which could be seen with the naked eye, or under low magnification. This method of Koch's made possible the first accurate ideas regarding the bacterial efficiency of filter plants and the regular testing of water for the abundance of its bacterial flora. The Franklands and others tested London's filter effluents, and for the first time it was known that there was a real basis for the general impression that had prevailed since the fifties that James Simpson's New Chelsea slow sand filters really made water safer, as well as better to look at and to taste.

To be sure Koch's gelatine plate method with its cumbersome bell glasses and heavily constructed leveling plates for the glass slips on which the media was poured, was too bothersome for the most extensive use. The Esmarch roll culture, the petri dish and Frau Hesse's introduction of agar-agar with its better solidifying powers and lessened likelihood of liquefaction under the action of bacteria, made the counting of bacteria easier and more capable of general use. But in that early day, Koch and some other workers made the arbitrary decision that 100 bacteria per cubic centimeter was a sort of dividing line between good and bad waters. In spite of the fact that differing temperatures, different incubation periods, different reactions of the media, and different cultural foods, all yield different results, the old figure of one hundred bacteria per cubic centimeter established with Koch's authority has held on. And so great is the inertia of the human mind, most of us feel easier if the bacterial counts on the supplies for which we are responsible stay below one hundred per cubic centimeter, and we become vaguely uneasy if the counts hover in the vicinity of the one hundred mark.

Science progresses from one enthusiasm to another. There was great enthusiasm over mere counts of bacteria in the eighties and nineties. A few plate counts were enough to justify a paper in a technical journal. The matter of bacterial counts might almost be said to have been "the hydrogen ion concentration of the eighties," to compare it to one of our later enthusiasms. There is always danger that in our intense interest and excitement over some new and promising phase of work, the actual importance and applicability of the process may be over-emphasized. And while it has a vogue, it is common for more to be claimed for a process than is actually justified. Time calms matters down. We have been learning this about the bacterial counts, at least during the last decade. We know more about the weakness of the counts, we are better able to use them understandingly and consequently we appreciate better their real value. As an indication of the trend, I would call attention to the lessened importance given to the matter of bacterial counts in the new Treasury Department Standard for water supplied to passengers in interstate traffic. The old 1914 Treasury Department Standard retained the time-honored value for the bacterial count.

But as supplying measures of filter efficiency bacterial counts are invaluable. They have their use in all types of water examinations, now that the Standard Methods of Water Analysis of the American Public Health Association and the American Water Works Association have made our results comparable over a period of time, and even to be compared with our neighbors works. But the bacterial count should not be abused in use.

We have had to realize the effects of time on samples collected for bacteriological examination, the effect of the temperature at which the sample was held, the effect of the reaction of the liquid, and that of the media, and of their mutual effect on each other and on the final result. We have learned that high bacterial counts usually follow copper sulphate treatment of reservoirs for the removal of algae and the consequent increase in bacterial food offered by the dead algae. Recent English work has called attention to the importance of algae growths in supporting and favoring the growth of Bacterium coli and Bacterium aerogenes in open reservoirs. And so we have realized that in some cases high bacterial counts may be practically without sanitary significance, unless it be that the food value of the water has increased.

In spite of the great amount of study which has been done, and the vast and astonishing bulk of literature which has been produced on the subject, the presumptive test for organisms of the colon group is still in active evolutionary modification. Most of the water works men of this generation can remember when a water was passed as safe if it failed to give a positive presumptive test for what was then called the Bacillus coli communis. Today we expect a public water supply to show not more than one positive test out of five plantings made with 10 cubic centimeters each of the water under test, and we expect even greater freedom when mass data is considered.

We are accustomed to say that the standards in this regard have been raised, and raised rapidly. But is this really so? We must not forget that while we have been demanding greater and greater freedom from the organisms concerned, measured in terms of the volumes handled, we have been restricting more and more closely what is meant by the members of the colon group, and we have become much more definite as to the characteristics of the Bacterium coli itself. In the later work many organisms which gave positive results with the old method have been excluded. Among these excluded forms are spore-forming bacteria, and bacteria that can ferment dextrose, but not lactose. These tendencies in the conduct of the presumptive test have a compensating effect, for while we say that larger volumes of water must show freedom from the test organisms, we have left out of consideration certain bacteria that formerly were included among the positives under the older methods.

Nevertheless I should not want to leave the impression that we are not now producing and distributing better water than that which was supplied in the past. I am sure such an impression would be very much in error. Our methods of the sanitary survey, the chemical examination, and the rest have changed for the better also. Our plant equipment is better, better understood, and generally better operated than it used to be. Better water supplies are therefore possible and they are demanded, not only by the officials, but also by the public.

In all bacteriological routine work on water supplies there are about five essentials of a suitable method: 1.) it must have a simple and easy technique which can be carried out by others than highly trained specialists; 2.) the process must be reasonably accurate and definite in its results so that the results are not likely to be incorrectly interpreted; 3.) the amount of incubator space and equipment must be kept within reasonable bounds and within the means of the smaller plants, 4.) the cost of the materials employed in the work must not be excessive nor subject to much waste on storage, and 5.) the process must not be so slow in arriving at definite results that the information is obtained too late to allow of reasonably prompt changes being made in the water treatment accompanying the changes in the raw water supply. Our present methods leave much to be desired in these matters. The points which cause us most concern at present however are the matters of speed, and simplicity.

Fermentation of lactose broth is much more definite in its information of the presence or absence of organisms of the colon group than was the old dextrose broth. Nevertheless there are a large number of so called "spurious presumptives tests" obtained in some localities. Sometimes these false tests run up to 80 or 90 percent of the positive fermentations. These results may be due to spore-forming organisms, either anaerobic, aerobic or facultative in nature. They may also be due to symbiotic associations in which a lactose-splitting, non-gas-forming organism is associated with a form which ferments dextrose with production of acid and gas. And of course there is always the possibility that other aerobic non-sporing bacteria may be involved. We are beginning to feel that all of the members of the colon group as now defined may not be of the same importance as indicators. But we are a bit hesitant about the application of the terms "fecal" and "non fecal."

As has already been mentioned, the amount of literature on the colon group is stupendous. There have been countless schemes proposed as remedies for the confusion which has persisted. The work on the fermentation of different sugars has opened up the path to the determination of endless varieties. Yet it does not solve the matter. Neither is it entirely without value. The use of phenol, of bile, and of various dyes have all had their advocates who were eager to advance with series of results showing that the method proposed had in their hands been surprisingly satisfactory in results. Others have studied the products formed, such as the gases, the amount of acid produced under special conditions, and the presence of certain substances due to bacterial metabolism of which the most famous are indol and acetyl methyl carbinol.

One of the characteristic things about water bacteriology is the high degree of impurity of the cultures worked with. There is little time for the isolation of various organisms. Neither is there time for incubation periods running up to several days. Some of the methods which have yielded best results in the hands of specialists have the defect of requiring most careful purification of cultures, or of taking from four to ten days of total incubator time. This is sufficient to rule them out of routine use. Other methods which have yielded the most satisfactory results on a particular supply have failed when applied to other water supplies. The variety of inhibitory materials used to restrain non-colon organisms is large. The most famous ones are phenol, bile, bile salts and the tri-phenylmethane dyes. Other procedures have been of the strangest sorts. The writer remembers one laboratory which had a most varied stock of all of the pre-war stains supplied by the well-known German makers. The stock was a reminder of an early director of the laboratory who had started out to find a differential stain for the colon organism.

As you all know, the tests for the organisms of the colon group according to the current Standard Methods of Water Analysis of the American Public Health Association and the American Water Works Association are placed under three heads, 1.) the presumptive test which is considered definitely positive when gas to the extent of 10 percent of the closed arm of the fermentation tube is formed in lactose broth in 24 hours, doubtful if gas is formed in smaller amount in 24 hours, even tho larger amounts are formed within forty-eight hours or if gas appears in 48 hours and definitely negative if there is no gas production within 48 hours. 2.) the partially confirmed test when material taken from positive or doubtful fermentation test is streaked on some confirmatory medium such as endo or eosine methylene blue agar and the aerobic growth examined for typical colonies. 3.) the completed test when typical-appearing or doubtful colonies are fished from the confirmatory plate and planted in a secondary lactose fermentation tube and on the surface of an agar slant. In the completed test the secondary lactose tube is examined for gas and if it is positive, the agar slant is examined for spores. If there are spores with other bacteria in the stained preparation from the agar slant, repurification of the culture is required, followed by additional plantings for gas in lactose broth and on agar for the detection of spores.

The presumptive test then requires 24 to 48 hours, the partially confirmed test 48 to 72 hours, and the completed test 72 to 96 hours, even in the absence of complicajtions requiring re-purification. The effort at the present time is to develop a test which will give greater certainty to the presumptive test within the time used by it, or enable a test of about the same value as the completed test to be carried thru in the time required at present for the partially confirmed test.

The very high percentage of false presumptive tests noted on some supplies makes it highly desirable that these spurious positives shall be prevented from masking positive presumptive tests actually due to the presence of the colon group. A considerable number of the organisms which are responsible for the formation of gas in these false presumptive tests are very resistant to chlorine. Indeed it is common to find that they will resist any feasible amount of that gas as used in water purification. The writer feels that these organisms may be of significance in the examination of untreated waters, but that in the filtered and chlorinated waters in which they are sometimes found, they have no importance unless they themselves are pathogems. This does not seem likely in most places, since they have existed for long periods of time in the waters both prior to and following the installation of treatment. It is frequently stated that the false positive fermentation results are due to the Clostridium welchii, but this is not necessarily true. Too many organisms, such as the B. macerans, which have been recovered from waters showing false presumptive tests are obviously organisms other than Clostridium welchii. Reference to symbiotic forms has already been made.

While the writer feels that these non-confirming forms of bacteria should by no means be given the same interpretation as is given to the members of the colon group when treated waters are being examined, nevertheless he feels that it is desirable to have an idea of the number of organisms of all sorts which will affect the ordinary lactose broth fermentation test. When these remain too numerous in a filtered water, they throw doubt on the adequacy of filtration and coagulation, and suggest that the efficiency of the plant is not what it should be. Frequently the numbers of the non-confirming spore-formers can be reduced by an increase in the amount of coagulant, but there must come a time when the further addition of coagulant is not justified from the economic view point.

Attempts to prevent the effect shown by these non-confirming organisms has been handicapped in the past by the fact that the methods used in one locality have not given corresponding results in other places. In an attempt to secure the widest spread of experiments with a certain inhibitory media, brilliant green lactose peptone bile, the committee on Standard Methods of analysis of the American Water Works Association secured co-operation thruout the entire country on its problem. Thousands of plantings were made on waters in many states and the positive tubes were carefully put thru the confirmatory tests. The result of this extensive study convinced the men who were conducting the work that the medium as then prepared was not satisfactory as a medium to replace the present standard lactose broth in spite of the disadvantages of the latter in giving so many false positive results. At the present time a definite and carefully planned study is being carried out on brilliant green bile to see if the proportion of the ingredients can be more advantageously adjusted. The men who are being most active in this phase of the work are Mr. McCready, of Montreal, Dr. Norton, of Chicago, Mr. Dunham, of Detroit, and Dr. Levine, of Ames, Iowa.

The trouble found with the brilliant green bile was that it was too inhibitory, as have been most of its predecessors in the special media of this type. The use of the brilliant green bile as a secondary fermentation medium has been studied by a number of other workers under the direction of Mr. Harry Jordan, of Indianapolis. The process involving secondary fermentation is necessarily slower in giving final results than the direct fermentation, but it has the advantage of allowing the growth in lactose broth of the weaker organisms until developed in sufficient numbers to prevent the inhibitory action of the medium from being likely to lead to an incorrect result. An additional advantage of such a procedure is that the laboratory work requires less experience and less familiarity with the organisms when growing as colonies. If there is fermentation in the secondary tube the colon group is indicated, and it is not usually necessary to prepare streak plates and to examine for typical colonies. Country wide results have shown that the method has a high degree of accuracy.

Among the other procedures and methods which seem to merit further study are the citrate method process of Koser, and the scheme to sub-divide colon group organisms into the so-called fecal and non-fecal types. In regard to the latter sub-division it is important to reserve judgment until much more definite data is available. The tendency of certain persons in the water industry to throw out of consideration all positive results due to the so-called non-fecal forms, needs to be kept in mind. If the bacteria actually are non-fecal then they obviously have less sanitary significance, but if the organisms are diregarded under the present state of conditions, some harm may result.

Without going into the matter of fecal and non-fecal types, it seems logical to suppose that the various members of the colon group themselves may differ in their individual sanitary significance. Following Levine, it is now customary in many laboratories to split the colon group into the Aerogenes Section and the Coli Section. The former seem to be rather more resistant to the usual processes of water purification and more persistent under stream conditions than do the members of the Coli Section. They might therefore be expected then to persist after the death of the true Bacterium coli and of the typhoid organisms. It would seem logical to believe that the presence of the Aerogenes Section alone would indicate an older pollution and hence a less dangerous one than when the members of the colon group also include the Coli Section. But in the present state of our knowledge it is best perhaps to give the presence of the Aerogenes Section almost as much attention in treated waters as is given to the presence of the Coli Section. In untreated waters of wells, the presence of the non-confirming gas formers or the members of either section of the colon group are evidence of entrance of surface waters, or imperfectly filtered ground waters. The significance of all gas formers therefore is more nearly the same.

The experience of the writer convinces him that the bacteriological examination alone can not be depended upon to give with certainty a measure of the actual state of the quality of the water being considered, recent published statements to the contrary notwithstanding. It seems more logical to attempt to supplement the bacteriological examination — especially on supplies being examined for the first time — with the full chemical sanitary examination, and with such other determinations as seem to be indicated. A sanitary survey by a competent person should always be made if possible. Bacteriological examinations alone give most nearly definite information on supplies with which the analyst is closely familiar, and on waters which have been subjected to artificial purification of one sort or another.

We need to beware of interpreting a given result in a given way irrespective of other conditions. We need to consider carefully what each result may mean under a given set of circumstances. Our conclusions will of necessity become more valuable as we ourselves become more experienced with the water supplies and the underground conditions of any particular locality.

Almost all of the determinations which we make provide us with indirect yardsticks. They are of value only in so far as the assumptions on which they are based remain correct in the case being studied. We do not know the whole story about the safety of water, or about the specificity of the various types of treatment employed in our work. Neither do we know all that we could wish to know about the possibilities of the water carriage of such things as anthrax organisms, foot and mouth disease virus, and various parasites. Some of these resist chlorine quite strongly.

Our business in water examination is of course to approve water supplies which are safe and to call attention to the dangers of those supplies which are suspicious or definitely unsatisfactory. While it is of course the part of wisdom to endeavor to insure any error in judgment being on the side of safety, we must remember that we are liable to cause considerable economic loss unless we are reasonable in our demands. Bacteriophobia is not what we are trying to bring about. We ourselves must not be slaves to old and worn out conceptions, nor must we make fetishes of certain numerical values.

Opinions obtained by consideration of the whole evidence are what we need. Rational opinions they must be. We do not want to be like the man told about in a recent number of the American Legion Weekly. When one of his friends inquired why he had disposed of the cemetery lot he had purchased, he replied that he had sold the lot because on the lot next to his they had buried a man who had died of a communicable disease.

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