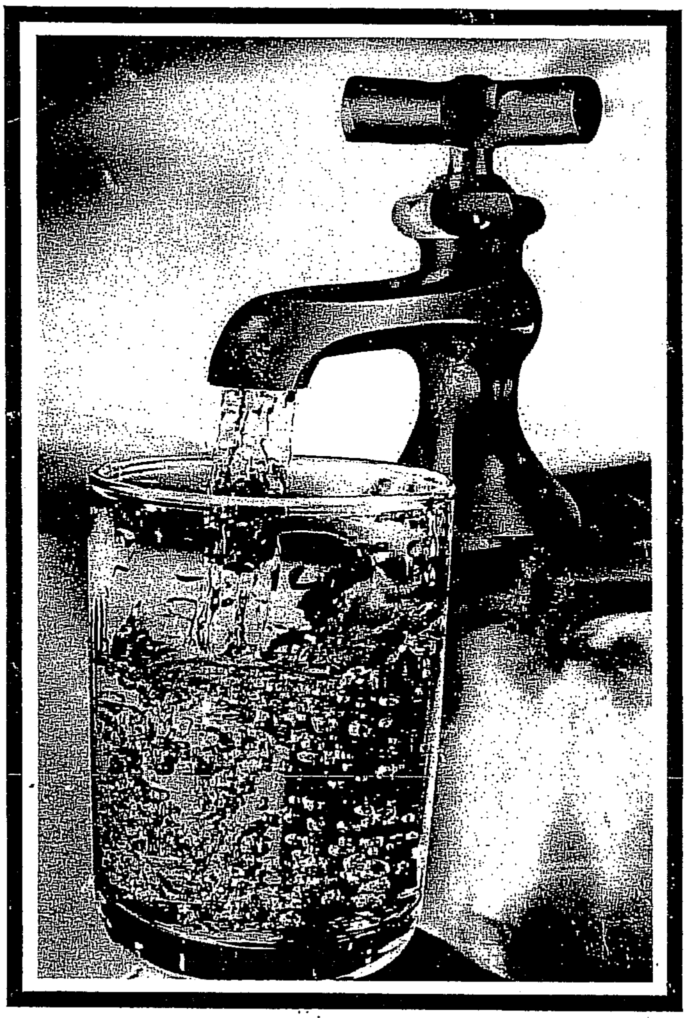

DRINKING WATER AND HUMAN HEALTH

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PREFACE

In recent years, there has been increasing concern with the quality of public and private drinking water supplies in the nation. This concern has been caused by fears of possible adverse health effects from contamination of potable water supplies with inorganic or organic chemicals, and from microbiological contaminants associated with waterborne disease outbreaks.

We hope this information will have significance in bringing to the attention of the scientific community and the general public the environmental health concerns associated with drinking water, and will fulfill the following objectives:

1. Outline the role of governmental agencies at the local, state and federal levels in improving drinking water quality through the provision of the Safe Drinking Water Act of 1974;

2. Identify the human health effects of a broad range of biological, radiological and chemical agents in drinking water supplies;

3. Review the relationship of organic constituents in water to the frequency of cancer in human populations;

4. Review the present state of knowledge regarding the relationship of drinking water and cardiovascular disease;

5. Review the application of health information in decision making for hazardous agents in drinking water.

We acknowledge with gratitude the dedicated assistance of the following individuals who assisted so ably in preparing the manuscripts for publication: Catherine A. Campbell (AMA), Nancy T. O'Connor (AMA), Leatha A. Tiggelaar (AMA), William L. Lappenbusch, PhD (EPA), and Susan B. Moskowitz, MPH (EPA).

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HISTORICAL REVIEW OF DRINKING WATER

Charles C. Johnson, Jr.

Next to the air we breathe, the water we drink is the most important part of our human existence. It has been said that a person can live 5 minutes without air, 5 days without water and 5 weeks without food. History has repeatedly warned us that each of these substances must be safe for human consumption if they are to serve their most beneficial purpose.

My role is to present a brief historical review of drinking water. This review will embrace 3 periods that seem to set out significant changes in approaches to producing acceptable drinking water. I have characterized these periods as:

1. Ancient - That period from the earliest recorded knowledge on water quality to the years just preceding the advent of the germ theory of disease;

2. Progressive - That period following the establishment of the germ theory of disease (approximately 1880) through the control of bacterial and other acute waterborne diseases;

3. Contradictive - The period that indicated concern for water contamination and lifetime or chronic health effects.

The Ancient Period

The ancient period covered a time when most population groups depended upon individual initiatives for the quality of the water consumed. The one prominent exception to this was the water supply for the city of Rome, which had its beginning about 313 BC. From the earliest of time humans have exhibited a concern for the quality of water they drink. As early as 2000 BC a quotation in Sanskrit said, "It is good to keep water in copper vessels, to expose it to sunlight, and filter through charcoal." Later, in his writings on public hygiene, Hippocrates (460-354 BC) directed attention principally to the importance of water in the maintenance of health, but he also stated that rainwater should be boiled and strained or it would have a bad smell and cause hoarseness. We are told that Cyrus, the great King of Persia, when going to war took boiled water in silver flagons loaded on carts drawn by mules.

From earliest time water has been treated by one of the processes we now take for granted -- sedimentation, coagulation, filtration, disinfection. We still use the same general principles to treat water today. These precautions probably were taken more for aesthetic considerations than for health purposes, yet they do illustrate an early concern for water quality.

Historical records indicate that standards for water quality, except for occasional references to aesthetics, were absent up to and including most of the 19th century. Yet some advances were made in the processes of community water treatment. The first municipal filtration works was built in Paisley, Scotland about 1832. The historical basis for requiring water treatment emanates from the mandating of this treatment technique. A law was passed in 1882 in London that henceforth all water should be filtered. This occurred approximately 10 years before Pasteur and others demonstrated the germ theory of disease.

Apparently ancient people deduced by observation, and in the absence of scientific proof, that certain waters promoted good health, while others produced infection. And though they knew little or nothing about the causes of disease, they must have, in some instances, recognized the health-giving properties of pure, wholesome water. Unfortunately, the record suggests that a century of observations on deaths caused by waterborne diseases was necessary to clarify these facts.

Not until the cholera epidemics of the 1800s was a clear cut relationship established between water and disease. We are familiar with the classic study of Dr. John Snow that linked the Broad Street well in London to the transmission of cholera. It is important to emphasize again that in Dr. Snow's time, the germ theory of disease had not yet been established.

We may reiterate several important points. The concern for the quality of drinking water has existed since ancient time. Early movements toward improving drinking water quality through treatment were not predicated on a scientifically-based, cause and effect relationship. And the main problems associated with drinking water quality were directly related to the concentration of population and to the waste disposal practices of the time.

The Progressive Period

The progressive period, which began about 1880, was characterized by rapid improvement in, and wide acceptance of, water treatment technology, control of waterborne bacterial diseases, and passage of national legislation and promulgation of standards designed to assure safe drinking water.

In the US, cholera was not a problem after the mid-1800s, the waterborne disease of particular concern being typhoid fever. Research proved the efficacy of the slow sand filter in reducing the death rate from this disease. Much of this is attributed to the Lawrence Experiment Station established by the Massachusetts Board of Health in the late 1800s. The use of slow sand filtration by the Lawrence Experiment Station demonstrated a 79% reduction in the death rate from typhoid fever and a reduction in the death rate from all causes of 10%.

The popularity of the slow sand filter was soon surpassed by the essentially American innovation of combining coagulation and rapid sand filtration. Research carried out at the Louisville (Kentucky) Water Company at the end of the 18th and beginning of the 19th centuries led to widespread use of rapid sand filtration. The Louisville experiments showed that even the most turbid of waters could be treated successfully to eliminate the turbidity and color and remove about 99% of the bacteria present. These conditions were considered to be a standard by which the quality of treated water should be judged.

Then followed the most important advance in the history of water treatment practice. The introduction of chlorination occurred about 1908. Chlorination provided an inexpensive, reproducible method of ensuring the bacteriological quality of water. Nothing in the field of water purification has come into use as rapidly or as widely as chlorination. Chlorination was introduced about the time that adequate methods of bacteriological examination of water had developed, thus permitting an objective evaluation of the efficiency of treatment. It was easily demonstrated that it was possible to remove most of the bacteria in raw water, to 0.1% of the preceding concentration, a 10-fold reduction over that achieved by filtration alone. Since that time, continued improvement in chlorination and other water treatment processes has allowed the establishment of the more rigid standard of one coliform per 100 ml of treated water. This sequence of events also established the principle of attainability in the setting of water quality standards.

With the successful use of the basic water treatment processes of sedimentation, coagulation, filtration and disinfection, the essential features of water treatment techniques were known by 1914. Since that time, many engineering refinements have been made, but there have been no changes in basic concepts. Thus the stage was set for the development of drinking water standards. It is important to note that the availability of treatment technology has always influenced the development of standards for drinking water.

There were approximately 3000 community water supply systems in the US at the turn of the century. Health and sanitary conditions were still in need of improvement. The community water supply systems were contributing to major outbreaks of waterborne disease, since pumped and piped water when contaminated provided a highly efficient vehicle for the delivery of pathogenic bacteria. Fortunately, the Congress recognized that water supplies serving the public must meet minimum quality standards. The first standards of the US Public Health Service were promulgated in 1914. An MCL (maximum contaminant level) of 2 coliforms per 100 ml of water was established. With this, the concept of maximum, permissible, safe limit was introduced. Further, the importance of sanitary surveys to identify undesirable watershed conditions was stressed. Since that time, the national drinking water regulations have been amended five times (1925, 1942, 1946, 1962, 1974) up to and including the passage of the Safe Drinking Water Act in 1974. These modifications resulted in addition of new standards, strengthening of existing standards, and in 1974, broadening of their application from supplies serving interstate carriers to all community water supplies.

One set of deliberations of the advisory committee for the 1962 revisions to the drinking water regulations is worthy of comment. For the first time a regulation was included for a substance for which there was no clear cut data on a cause and effect relationship between level of the contaminant and the health of the consumer. The 1962 revisions limited the concentration of radioactivity in water. The effects on large population groups of chronic exposure to low levels of radioactivity were noted as "not yet well defined."

In 1962, scientific opinion held that potentially harmful radioactivity above background levels should be limited in our drinking water supplies. The Maximum Contaminant Level (MCL) could not be set with absolute certainty. The limits were an effort to derive an initial standard on the best information then available. It was recognized that the new standard might have to be adjusted upward or downward as better data became available. The inclusion of this standard emphasized the true measure of public health practices in producing safe water. The standard said "we do not know how bad it is for us, but we do know it is not good for us." The decision was made to limit radioactivity in drinking water based on the best information then available.

In retrospect, the success of this national effort is testament to the many persons in the water supply industry and the several levels of government that joined together in the effort that marks the progressive period. With rare exceptions, epidemics traceable to "waterborne diseases" are no longer a part of our way of life. People expect to travel anywhere in the United States and drink water without fear of getting sick. In other times and even today in other countries the accomplishment of that fact would be considered an idealistic dream. Yet the nation's water works industry, under the unifying controls of Federal and State health regulations, made that dream a reality in this country. Three ingredients were paramount to this success, an understanding of the problem, a willingness to overcome the problem, and recognition of the need to protect the public's health.

The Contradictive Period

The contradictive period was fashioned from the industrial progress that accompanied World War II, but its impact on drinking water was not recognized until the 1960s. There is mounting evidence that our water supply sources are being subjected to contamination by substances of unknown significance and public health concern.

Today over 700 organic chemical contaminants have been found in drinking water supplied by public water systems. Many are probably of no consequence, but others pose a potential health risk to consumers. Even when the contaminant is known to be harmful to the health of persons under some conditions of exposure, the significance of their presence in trace quantities in drinking water is unknown. We do know that given the option we would not knowingly add these contaminants to our water. They are not known to serve any useful purpose when taken into the human body in this manner. Yet, we are reluctant to take the steps necessary to bring this problem under control.

In earlier days, a concept prevailed that the public's requirements for a domestic water supply in both quantity and quality were guaranteed top priority in the hierarchy of uses of our water resources. Today they are captive of the need to produce energy, reverse the balance of payments and dispose of the waste products of our progress.

At one time, there was a regulation; and it was accepted practice, that water supplies be obtained from a protected source, and that every effort should be made to prevent or control pollution of water supply sources. Yet the sanitary survey has been all but abandoned, and our watersheds have become unprotected victims of community and industrial development, and unregulated waste disposal.

Many communities have had to abandon their water supply sources due to the discovery of contamination by synthetic organic chemicals for which we have been unable to establish acceptable limits and for which some say there is no current health problem. Yet these episodes have failed to spur the broad initiatives required to provide a rational determination of the need for taking such drastic steps.

We decry the practice of water reuse. Yet every community water treatment plant that exists below the discharge of a wastewater treatment plant is in a mode of unplanned reuse. Evidence abounds that major ground water aquifers are being contaminated by hazardous and toxic wastes. Yet we have not found it necessary to implement the corrective programs required to adequately control this threat to water supply sources for half the population of this country.

For a brief period, with the promulgation of an MCL for radioactivity in drinking water, the principle of preventive public health emerged. Now if we cannot count the patients in the hospital or the corpses in the street, we are reluctant to support comprehensive regulation of synthetic organic contaminants in our drinking water.

Many water treatment plants are experiencing difficulty in producing aesthetically satisfactory water and in removing or reducing the levels of these contaminants that come from raw water sources polluted with industrial, municipal and agricultural wastes. We are learning that water quality is dynamic. The products of population growth and industrial development are reflected in a deteriorating quality of our drinking water in many areas across the country.

Advanced water treatment techniques are being used in a number of water treatment plants in Europe to combat the presence of organic contaminants in their raw water supplies. It is estimated that more than 30 treatment plants in Western Europe are now using granular activated carbon (GAC) on a routine basis for removal or reduction of these chemical contaminants. While GAC is still a subject of research, a consensus seems to be emerging in Europe that the use of GAC is an essential tool for modern water treatment practice. This is a very different attitude than the one that prevails in this country on control of synthetic organics in drinking water.

A recent attempt to mandate the use of GAC treatment technology in American practice was successfully defeated. An effort is underway to amend the Safe Drinking Water Act in a manner that would make it more difficult to write regulations intended to protect the public's health. Some sources indicate that as far as trace levels of synthetic organic contaminants in water is concerned, no known harm is being done. Let us wait until we know what the health effects are. More research will tell us if and when we need to regulate these synthetic organic contaminants.

Should attitudes like these prevail in the national debate that is now underway, I see a bleak future for the continued progress of drinking water protection in this country. The water industry is not likely to voluntarily implement the changes required to improve the chemical quality of our drinking water. Our research efforts are unlikely to provide the degree of certainty required by the skeptics for support of new regulations. The funds required to protect and clean up our sources of water, already in short supply, are likely to face further reductions at the Federal level. Efforts to generate and promulgate national regulations will continue to be impeded by demands for cost benefit analyses which we should know in this instance are impossible to equitably assess.

Our only defense must be a public attitude that says, "An ounce of prevention is worth a pound of cure." Only then will we be ready to support the drinking water standards and construct the water treatment systems that are necessary to provide acceptable protection to the public health. Is it not time that we eliminate contradictions in our rhetoric about the safety of our water supplies and assume a preventive approach with respect to drinking water quality?

<u>Summary</u>

In this historical review, we have traveled almost 4000 years in time. A concern by the public for the quality of its drinking water has been and is ever present. We have seen that when we ignore the manner in which the population and industry dispose of their waste, our water supply sources are placed in grave peril, and often disease and death are the end result. If proper motivation is given, the technology and standards required to assure an acceptable quality of water under most circumstances can be made available. In the past, when a crisis was evident we were able to marshall our collective scientific, technical and political strength to resolve the problem at hand. It is unfortunate that history does not provide us the crystal ball that tells us what we should do before we pay the price for not having done it.

We do not have to wait for this to happen. I do not think we will ever know with any degree of certainty what harm our contaminated water is causing us. I do not believe this lack of knowledge provides anyone a license to produce contaminated drinking water that is potentially harmful to the public's health. In my opinion, we must move ahead on the basis of the best evidence that is available to produce the best water that we can. We do know these modern contaminants are not good for us, we just do not know how bad they are for us.

The time is now for us to require the best treatment that technology can provide to protect the public from the myriads of toxic chemicals we have discharged to our environment and which ultimately find their way into our water supplies. I believe the time is now for us to adopt a non-degradation policy with respect to the quality of the water we drink. I believe the time is now for the American public, its legislators, and its regulators to say we are not going to play Russian roulette with our health and the future posterity of this nation. What specifically should we do? I hope this meeting will provide some of the answers, influencing the movement toward better drinking water quality for years to come.