HEALTH AND THE SAFE DRINKING WATER ACT

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Public Law 93-523, the Safe Drinking Water Act, requires the U.S. Environmental Protection Agency (EPA) to promulgate several types of drinking water regulations. The first is called the National Interim Primary Drinking Water Regulations. These interim regulations were published in the Federal Register on Dec. 24, 1975, and will take effect nationwide on June 24, 1977. These regulations are termed "interim" because the act also provides for a study by the National Academy of Sciences (NAS) of drinking water contaminants, and requires the interim regulations to be modified -- if necessary -- as a result of that study. The modified regulations will then be termed the Revised National Primary Drinking Water Regulations. The NAS study is currently underway. By either name, interim or revised, the primary regulations are to be nationally applicable and are to address matters of health. Since some contaminants of drinking water are undesirable for reasons other than health, such as iron and manganese and their attendant problems of staining, the act provides also for National Secondary Drinking Water Regulations. EPA is in the process of preparing these regulations at the present time. I have a copy of some of the material proposed for the secondary standards and will comment later. However, I would like to observe at this point that the Act states that EPA shall consult with both the U.S. Department of Health, Education, and Welfare and with the National Drinking Water Advisory Council in promulgating both the primary and secondary regulations. The interim primary regulations are even more interesting for what are not specified than for what are specified. However, I would like first to review the criteria that are specified, and in this review skip the material relating to turbidity and coliforms which concerns the microbiological integrity of drinking water supplies. Communicable diseases have long been a part of federal authority and are not the reason the Safe Drinking Water Act was passed. The Act was necessary in order to get control over chemical substances in drinking water, an authority the federal government never had, even though it was exercised.

In looking at the chemical substances and their health effects, it is necessary to remember that drinking water is only one of several routes by which a toxicant can be conveyed to the body. Limits for toxic materials must be based upon total intake which must include the air we breathe, the food we eat, and sometimes even direct skin contact. In prescribing the con-

centrations allowed in drinking water, it is asumed that an individual consumes 2 liters per day.

Arsenic

A dose of arsenic clears the human body in about 10 days and hence is accumulable over only a relatively short time. It has both kidney and liver consequences. It can occur in the pentavalent or trivalent forms - the latter being most toxic. Its occurrence is restricted mostly to groundwaters in areas subject to volcanism in ages past. However, it can also be found in industrially polluted waterways. The limit of 0.05 mg/l applies to total arsenic since the pentavalent form can reduce in the gut to the trivalent.

The 1962 U.S. Public Health Service (PHS) Drinking Water Standards contain a mandatory limit of 0.05 mg/l and a recommended limit of 0.01 mg/l for arsenic. The latter value was based on some unclear evidence that arsenic might be a carcinogen. In the last ten years, rather intensive study of arsenic has failed to document its carcinogenic properties in laboratory animals. Epidemiological studies of families using well water containing contrations of arsenic of 0.09 to 0.12 mg/l and even higher has failed to demonstrate any effects. A limit for arsenic of 0.1 mg/l was about to be proposed when an occupational cancer episode broke into the news, and hence the 0.05 mg/l mandatory limit was retained. Arsenic is a sulf-hydryl active metal and consequently exhibits additivity with other sulf-hydryl active materials. We'll return to this subject later.

Barium

Barium is a recognized muscle stimulant particularly effecting the heart muscle. It can also cause nerve block and produces a transient increase in blood pressure by vaso-constriction. Its occurrence is again mostly confined to groundwaters. Since no studies had been made of the amounts tolerable in drinking water, the standard for barium provides the classic example of how a drinking water standard can be fashioned from an air standard and which is based upon total intake concepts.

Cadmium

Cadmium is well-recognized as a highly toxic material. Many acute toxicity episodes are on record based upon contamination of food and beverages. One of the most severe occurred in Japan, resulting in a severely crippling and painful Itai-Itai (ouch-ouch) disease. Its presence in water may be from industrial waste discharges and/or from galvanized piping in which cadmium is a contaminant. Its most serious aspects concern chronic damage to the kidney and interference with uncoupled oxidative phosphorylation, an important pathway of metabolism. The late Dr. Henry Schroeder's studies on rats indicated that even the low standard of 0.01 mg/l may be too high over a lifetime of human consumption. It is also recognized that some compounds of cadmium are occupationally carcinogenic.

Chromium

The 1942 PHS Drinking Water Standards had set a limit for hexavalent chromium of "shall not be allowed" -- in other words, none. One of the members of the committee on revision of the standards operated a water system in which some of the wells had 0.02 or 0.03 mg/1 concentrations of hexavalent chromium. To get his wells back in service, he prevailed upon the rest of the committee to raise the standard in the 1946 revision to 0.05 mg/1 -- just high enough for his wells to qualify. This is the "scientific" way by which we acquired our drinking water standard for chromium. It stayed the same in the 1962 revisions but in the current primary regulations the 0.05 mg/1 limit now applies to total chromium, not just to hexavalent chromium. Although some toxicologists believe trivalent chromium to be an essential form of the element, this is apparently not universally accepted. The chronic concern aspect appears to relate mostly to the known carcinogenicity of some chromium compounds when inhaled.

Lead

Most everyone has heard of the hypothesis that Rome's decline and fall can be attributed to lead poisoning of Rome's elite citizenry. One of the interesting anecdotes comes from Herschel Clemens who reports that the Marcian aqueduct provided the coolest, softest waters to Rome and that these waters were much in demand. Since lead piping was used at the time, and we now know what soft waters can do to lead pipe, we can guess as to how some lead got to Rome's leaders. Lead is a cumulative poison of the bone and is increasing in our modern environment. The increases relate mostly to leaded fuels and this is the main route EPA has chosen to control the problem. Lead and a number of other metals -- arsenic for one -- have an ability to react additively with the sulf-hydryl active group. Hence, protective enzymes that utilize the sulf-hydryl group will be impaired in their function. One of the cancer hypotheses concern environmental chemicals reacting with protective enzyme systems, thus lowering human resistance to carcinogenic agents. Certainly, lead, arsenic, and all related sulf-hydryl active agents are deserving of concern in this respect. The Soviet Union has limits for lead and arsenic of 0.1 and 0.05 mg/1 respectively. A Russian scientist observed that when present together, one or the other limit should be halved in order not to interfere with the sulf-hydryl system used in her tests. This would defend the U.S. limits of 0.05 mg/1 for each.

Mercury

Metallic mercury -- not airborne mercury vapor -- is rather inocuous. In the environment, however, it biologically converts to methylmercury. This can happen under aerobic or anaerobic conditions. Methylmercury is highly toxic, attacks cells of the nervous system, and has been responsible for the tragic Minamata disease episode in Japan. The Russians have long had a limit of 0 005 mg/1 for mercury in drinking water, and when the mercury episode arose in the U.S., Public Health Service scientists derived the same limiting concentration. The new primary regulations specify a limit of 0.002 mg/1 which is totally defensible. Mercury occurs mostly in groundwaters in areas containing mercury ores (cinnabar) and in waters contaminated by industrial wastes.

Selenium

Information on the toxicity of selenium is extraordinarily complex and controversial. Example 1 - there is evidence that it is an essential element, but this is not completely accepted. Example 2 - arsenic in drinking water accentuates the toxicity of selenium in drinking water, but when the selenium is in food, arsenic protects against selenium toxicity. Example 3 - selenium present in seliniferous grains is more toxic than inorganic selenium added to the diet. Example 4 - selenium administered to rats in drinking water increases dental caries. Studies in humans both support and refute these observations. Example 5 - Selenate administered to rats, from weaning till death, in drinking water was not toxic in terms of growth, survival, or longevity, but administered to older animals was both tumorigenic and carcinogenic!

Since selenium is cumulative in the kidney and liver and is of concern as a carcinogen, its limit of 0.01 mg/l in the 1962 PHS Standards has been retained in the new EPA primary regulations.

Silver

The effects of silver are chiefly cosmetic, relating to argyrosis. In high concentrations it can damage the kidneys, liver, and spleen. A standard was considered desirable a number of years ago when it was observed to be an effective disinfecting agent. Its cost is now so high that there are few places in the U.S. -- if any -- that use it for disinfecting water. Further, not much silver is allowed to escape from industries that utilize it -- again because of its cost. Nevertheless, the level of 0.05 mg/l has been retained.

Fluoride

The fluoride story has been widely publicized for many years. Its natural presence in drinking water was found to be related to a low caries incidence, and when present at too high a concentration caused mottled teeth. Consequently, it was added to water supplies in a controlled amount to protect against caries and was found to be highly effective. Since then it has been observed to be beneficial to the elderly by helping maintain stronger bones. The addition of fluoride or any other similar agent to drinking water is addressed in Section 1412 (b) (6) of the Safe Drinking Water Act. "No national primary drinking water regulation may require the addition of any substance for preventive health care purposes unrelated to contamination of drinking water." Hence, the primary regulations for fluoride are to protect against fluorides being present at too-high concentrations. In other words, Congress recognizes the social nature of some decisions -- which we should all recognize will become an increasing part of our daily lives as time passes. Witness the atomic energy program's problems, and the concern about wastewater reuse.

Nitrates

The nitrate limitation is to protect infants against methemoglobinemia. Its very presence in the 1962 PHS Standards and in the new primary regulations raises an exceedingly interesting point. Infants comprise a highly visible, identifiable part of the population. It is easy to specifically identify them as individuals who should use another water supply if an existing supply contains more than a 10 mg/l concentration of nitrates. Yet, we are going to make all drinking water supplies meet this limitation in order to protect this highly visible part of the population. But in the case of sodium, which is not limited in the interim primary standards, we have a material that is of concern to an estimated 21 to 27 million Americans most of whom do not realize they should be concerned. Further, there is no certain way by which every individual can determine their own vulnerability beforehand. It seems to me that something is seriously out of order in-so-far as our approach to nitrates and sodium is concerned.

Pesticides

The primary regulations establish limits for chlorinated hydrocarbon insecticides and for chlorophenoxy herbicides. The chlorinated hydrocarbons as a class of chemicals are man-made and exhibit, in general, long-term residence in the biosphere. The concern for their effects on mammals relates to the nervous system, primarily the brain, and to tumorigenesis.

The limitation for methoxychlor is based on both human and animal studies and incorporates a 10-fold safety factor. Since there are no human data for endrin, lindane, and toxaphene, a 500-fold safety factor has been used in setting limits. There also exists no human data for the herbicides' toxicity and a similar 500-fold safety factor has been incorporated in setting limits for these substances.

Organics

A general limitation for toxic organic materials -- other than for the pesticides -- is missing from the interim primary regulations. The finding of carcinogenic organics in the drinking water of New Orleans supplied the main reason for passage of the Safe Drinking Water Act. EPA is busy conducting studies to find out what organics are present in today's drinking water supplies and at what concentrations. Some of these studies relate to chloroform and other halomethanes which are formed as a byproduct of chlorination when precusor organics are present. Control possibilites include carbon adsorption treatment to remove the precursor organics, or using ozone in lieu of chlorine as the disinfecting agent. Congress recognized that it is not possible to specify no-effect levels for all toxicants. In these situations, the Act states that EPA shall specify the treatment techniques that are to be used. This opens the door to a social decision since cost must be taken into account. Science and technology cannot always supply decisions, but they can supply information upon which more rational decisions can be made.

Secondary Regulations

The first materials I've received relating to the proposed secondary regulations indicate that EPA is considering limits for chloride, color, copper, methylene-blue active substances (MBAS), iron, odor, manganese, and sulfate that are essentially identical to those recommended by the 1962 PHS standards. These limits are:

Chloride, mg/l	250
Color, units	15
Copper, mg/l	1
MBAS, mg/l	0.5
Iron, mg/l	0.3
Odor, number	3
Manganese, mg/l	0.05
Sulfate, mg/l	250

The limits are suggested to prevent esthetic problems due to taste, odor, color, foaming, or staining. For copper, manganese, and sulfate, however, there exist health aspects. Since "esthetic" problems from these substances occur at lower concentrations than health problems, the substances are not limited in the primary regulations. Yet Congress stated that, "Both primary and secondary drinking water regulations may be established for the same contaminant, if the statutory criteria are met."

The limit for sulfate "was chosen to afford a reasonable factor of safety against having drinking water cause a laxative effect." EPA considers a chemically induced diarrhea to be an esthetic problem, not a health problem!

Sodium is discussed in the proposed secondary regulations, and the discussion is excellent. Everyone should read it. Individuals on a 500 mg/day sodium diet should not drink water with a sodium concentration more than 20 mg/l. Individuals on a moderately restricted sodium diet should not drink water of more than 270 mg/l sodium content. However, a specific limiting concentration for sodium -- a sodium "Standard" -- is not proscribed. The discussion recommends that the sodium content of drinking water supplies be provided to local physicians, and also states that "Special efforts of public notification must be made for supplies that have a very high sodium content..."

My personal feeling is that the discussion on sodium belongs in the primary -- not the secondary -- regulations along with that of sulfates. It is not necessary that EPA set a maximum contaminant level for either of these substances because of the high cost associated with removing them. (The Safe Drinking Water Act allows for this.) But concentrations of sodium and of sulfate in excess of 20 and 250 mg/l respectively should be continually reported to the public -- not just the local physician. As far as copper and manganese are concerned, limits for these substances also belong in the primary regulations even if the health limit proves higher than the limit based

upon esthetics.

I would like to conclude with two thoughts that pertain to the National Drinking Water Advisory Council. First, the members of the council are quite aware that specifying substances and limits for substances in drinking water is not entirely the preventive mechanism we would all like for it to be. Coliform results, for example, are obtained days after the waters are drunk. The most effective means of protecting the integrity of our water supplies is through the sanitary survey and the many preventive aspects associated with it: trained operators, sound equipment, adequate pressures, protected sources, and appropriate treatments. Hence, the council has been emphasizing from the beginning the importance of the sanitary survey. I am reminded of the words of a PHS medical officer in 1919: "Water supplies heretofore have been passed upon by bacteriological standards. Very little attention has been paid to (sanitary) survey standards which engineers would likely set. I think the time has come to adopt the engineering point of view. The bacteriologist will only be a checker-up and I think I can convince you ... that we should adopt the (sanitary) survey method of accepting a water supply rather than the bacteriological." The sanitary survey is today still the most important preventive function concerning our water supplies. Limits for bacteria, chemicals, etc. constitute only the "check-up" part of the program.

Lastly, I wish to commend the National Drinking Water Advisory Council for the diligence it is displaying in carrying out the advisory function and Mr. Russell Train for his effective leadership and willingness to respond to the council's advice. Were it not for Mr. Train, the council would be just another ineffective appendage of the bureaucratic process.