Sociological and Technological Factors in Developing Water Quality Criteria

M. B. ETTINGER

IN 1838 Comte defined sociology as the comprehensive, objective study of the associated life of man. By any definition, the needs and desires of society require regulations and standards that describe collective and individual desiderata and restraints. This discussion will consider only the development of criteria that interpret social needs and interests in water pollution control.

Man is the only animal in the gross ecology capable of applying massive amounts of engineering skill or sheer unthinking nonsense to drastically alter the characteristics of his environment. Of course, there are minor operators like the beaver, but his efforts are of a magnitude less effective than those of man. As men, our sociological response to environmental alteration should be one of intelligent self-interest. We are interested in the effects of aquatic environments on fish, not because we are concerned with a wholesome environment for fish, but because they are important to men who like to fish or to eat fish. The specialized biologist may dote on caddis flies or rattail maggots, and water quality criteria could be designed to promote the interests of the caddis fly fancier or the rattail maggot fancier; however, socially acceptable criteria must seek to protect and develop the integral interests of society.

The major interests of society in the usage of water resources are these broad considerations: recreation and esthetic enjoyment, a supply of water for drinking and culinary purposes, and a supply of water to do work. Work includes such domestic tasks as flushing the toilet or conveying ground garbage from the home and the full spectrum of industrial water usages including irrigation, cooling, industrial process water, growing fish for commercial harvesting, generating power, or economical water movement of freight.

Mr. Ettinger is chief, Chemistry and Physics Research Branch, Division of Water Supply and Pollution Control, Robert A. Taft Sanitary Engineering Center, Public Health Service. The paper was given at the annual meeting of the American Chemical Society on September 11, 1962, in Atlantic City, N.J.

Consideration of economic uses is the rational means of analyzing sociological interest in water quantity and quality. This has been bravely proposed many times, and a recent approach by Kneese (*1*) has merit. However, the economist is continually harassed by emotional factors which do not readily fit behind a dollar sign.

The Declaration of Independence insists that the citizen is entitled to "life, liberty, and the pursuit of happiness," and we receive continuing assurances that these are the priceless heritage of every citizen. Drinking water quality certainly is a factor in life, and, even recently, lapses in quality control have clearly cost life. The pursuit of happiness is a factor that enters into water quality every time we try to assess the value of beauty, fish, or motorboating. If one investigates the annual expenditures for waterfront vacations or fishing licenses and equipment, or for motorboats and their operation, he is forced to put a high price on recreation and esthetic values. There are measurable dollar values placed on waterfront real estate or even on real estate with a good view of the river. Unquestionably, the public elects to pay a huge price for aquatic enjoyment. But there still remain equities hard to describe in terms of dollars. How, for instance, do you value a good-tasting drinking water unless it gets so bad that people pay money for bottled water?

The pursuit of happiness includes the pursuit of money and even the pursuit of subsistence. Although it is difficult to price pursuit of happiness as a right, it is possible to estimate the cost of precedures required to facilitate the pursuit of happiness. Kneese has stated this as follows: "It is possible to indicate what the least value is that must be attached to the increment of pleasure in order to make this level of control procedures worthwhile."

The pursuit of subsistence is clearly a brake on regulations designed to promote the pursuit of happiness. The city of Detroit, for instance, delivers treated water to the industrial consumer, receives his waste water, and prepares it for disposal for an average cost of about $1 per 1,000 cubic feet (*2*). In competing for water-using industry, other communities cannot greatly exceed this water cost. If water for municipal usage must be recovered from saline water, the cost would increase tenfold and would severely restrict the type of community activity that could be supported in competition with the present Detroit price.

Emotional and traditional values, sometimes codified in the form of riparian law, can give an uneconomic priority to an established water usage for subsistence. The acre-foot of water used by dry industry (*3*) may support activity worth 10,000 times as much as the same acre-foot of water used in agriculture. The dry industry acre-foot of water may support employment of 2,000 times as many people as the agricultural acre-foot.

A recent sociological trend is the reduction of the labor force of the large water-using industries. The man-hours per unit of product are dropping sharply for paper and steel manufacture, petroleum refining, chemical production, and other industries. A few local jobholders and a large amount of absentee capital look to these wet industries for income. The dispersed stockholders clearly have less influence than the wage earner next door in determining community and regional attitudes, and this trend is reducing local support for tolerant regulation of damaging use of water. Before too long we may see governmental intervention for rational industrial water usage rather than governmental intervention to protect the interests of the local citizen.

The associated living of man is becoming progressively more associated. In the Mississippi River below St. Paul more than 10 percent of the flow has recently been through the sewers of Minneapolis or St. Paul 1 day in 20. More than 5 percent of the water in the Ohio River at Cincinnati has been through the sewers in 1 of 15 of the larger upstream cities as municipal water whenever the flow is below 13,000 cubic feet per second. This happens about 35 days a year.

In agriculture, chemicals are applied to the land which could make significant changes in the characteristics of surface water. If our annual agricultural consumption of nitrogenous fertilizer were evenly dispersed in the annual runoff of 1,160 billion gallons per day, about 3 ppm of nitrogen would be added. Similar dispersion of agricultural phosphate would add more than 1 ppm, and the annual consumption of insecticide (*4*) would add an average insecticide concentration of 0.13 ppm.

Many of man's direct interests in water quality are incompatible. If water is used to flush away the pound of calcium chloride and the half pound of salt that are wasted each time the alkali industry produces a pound of Solvay-process soda ash, the receiving stream is likely to become unacceptably hard and loaded with brine, especially since the Solvay-process soda ash plant is likely to come in 1,000-ton-per-day models (*5*). Wastes from a 1,000-ton-per-day Solvay-process soda ash plant will add about 100 ppm of solids to a stream that passes 5,400 cubic feet per second. Since high chloride content in water is incompatible with its use in the production of certain types of rolled sheet steel, we find, as we would expect, that one work-use of water makes it unsatisfactory for another work-use.

One recreational use of water can also interfere with other recreational uses. It is obvious that motorboating and swimming are mechanically incompatible. It is not equally obvious that relatively dense motorboating can so foul water with pollutants that the flesh of fish in the water is made unpalatable, as shown by unpublished studies by John English and coworkers of the Robert A. Taft Sanitary Engineering Center.

Air pollution can sometimes be abated in terms of intelligent self-interest because the air polluter fouls his own nest. The stream pollution problem does not so resolve itself when the water source and the liquid waste receiver are a flowing stream. The polluter can sometimes see large benefits from using the stream to receive his wastes and nominal benefits from treating those wastes; however, relatively large damage may be done to the downstream water user.

If we again consider the conveniently well-defined Solvay-process alkali plant, the cost of waste treatment may make this operation uneconomical; wastes from a Solvay-process plant can make a good-sized stream unsuitable as a source of municipal water and either totally unacceptable or relatively expensive for most industrial uses. We do not yet have adequate social tools for resolving this situation. The demand for pollution control can deprive the entrepreneur of the right to operate profitably in a given location. However, one cannot feel concerned about the contemporary manager who elects to establish an enterprise where the plant's water usage is incompatible with economical process-waste disposal requirements.

A difficult and still unresolved situation is that of the plant which was badly located years ago and which has now acquired a "grandfather clause" through decades of operation. A history of abuse of water resources cannot serve as a sound reason for continuing such abuse when it is contrary to the best interests of society.

There are two Solvay-process alkali plants which are questionable assets to the national economy, even though they remain commercially sound at the expense of water quality destruction that probably exceeds in value the productivity of the plants. Here is another economic enigma: How do you evaluate the lost water usage that did not develop because wastes made the water unsuitable for beneficial usage?

We have already stated that water quality criteria should define the integral interests of society. These criteria cannot be static since society is not static. Redefinition or extension may be caused by advances in analytical technique which yield new or better measures of quality or by new technology such as the development of atomic fission and fusion techniques. Redefinition may also be required for technically trivial reasons if this is the will of society.

In addition to defining acceptable social values, water quality criteria must have other characteristics.

1. They must be capable of measurement by clearly defined procedures.

2. The measurements prescribed must be of such nature that society can afford to use them.

3. A measurement or criterion, if it is to have legal status, should be interpreted in terms of inflexible values rather than by an interminable exercise of judgment. Of course judgment must be incorporated into the value selected.

Since the preceding criterion might seem obscure, perhaps we might cite a parallel in terms of highway usage. We do not see signs stating "speed limit 13–68 miles per hour depending on what is reasonable and prudent in terms of the general welfare." Instead we see official judgments like "speed limit 45." Such a behavior criterion is not always a precise optimum, but it certainly offers a practical and well-defined description of acceptable behavior.

This discussion would not be complete without consideration of the sociological aspects of the evolution of at least one water quality standard. Let us examine the Public Health Service Drinking Water Standard, the best known and best documented water quality standard in this country.

The legal authority of the Public Health Service extends to prescribing and enforcing standards of quality for water supplied the traveler by interstate carriers. Social pressures act to extend these criteria beyond the 800 certified municipal supplies to all public supplies within the nation. It is inconceivable that the residents of Chicago or New Orleans will accept a water supply deemed unfit for the interstate traveler. The American Water Works Association has accepted the standards; they are widely applied, and the association has a group working on the development of super quality standards.

In 1914, the first group which developed Public Health Service Drinking Water Standards decided to consider only "the furthest deviation from purity considered permissible"

(*6*). They also developed a sound and lasting philosophy of drinking water standards stated in these terms.

"1. That water supplies conforming to the prescribed requirements shall be free from injurious effects upon the human body and free from offensiveness to the sense of sight, taste, or smell.

"2. That supplies of the quality required shall be obtainable by common carriers without prohibitive expense.

"3. That the examinations necessary to determine whether a given water supply meets the requirements shall be as few and as simple as is consistent with the end in view."

The 1914 commission recommended only bacteriological limits principally because the control of waterborne disease was the most important water quality concern of the time. Without so stating, the first commission also established the principle that methodology for use in interpretation of the standards shall be described or stipulated as part of the document or as an official appendix thereto.

The 1925 revision of the Drinking Water Standards included sections on "Source and Protection" and "Physical and Chemical Characteristics" (*7*). In 1942 and 1946 the scope of the standards was extended to include control of water quality at the free-flowing tap of the consumer (*8*). In March 1962 the most recent revision of the Public Health Service Drinking Water Standards appeared as an amendment to the Interstate Quarantine Regulations in the Federal Register.

The ground rules developed by the advisory group for guiding the latest revision have already been described in some detail (*9*, *10*). Some recommendations that reflect social and technical pressures are: (*a*) a new section on radioactivity should be included, (*b*) greater attention should be given to the chemical substances being encountered in increasing variety and quantity in water sources, and (*c*) the rationale employed in determining the various limits should be included in an appendix.

In their report, the advisory committee stated:

"The Committee has taken cognizance of the growing problem of potentially harmful chemicals in sources of drinking water. Limits for several new chemicals have been added, including a gross limit for the concentration of some types of synthetic chemicals. It was not feasible, however, to include limits for all the many chemicals that have varying degrees of toxic potential. Consideration was given to the more common chlorinated hydrocarbon and organophosphate insecticides but the information available was not sufficient to establish specific limits for these chemicals. Moreover, the concentrations of these chemicals, where tested, have been below those which would constitute a known health hazard. The Committee believes that pollution of water supplies with such contaminants can become significant and urges that the problem be kept under closer surveillance. Further, the Committee recommends that regulatory actions be taken to minimize concentrations of such chemicals in drinking water.

"In view of the accelerating pace of new developments affecting water quality, the Committee recommends that a mechanism be established for continual appraisal and appropriate revision of the Standards. It also recommends that the Public Health Service intensify its continuing studies toward the development of basic information on the relationship of the biological, chemical, physical, and radiological aspects of water quality to health."

A task force on toxicology guided the advisory committee in toxicological decisions. The record of the evidence considered by this task force represents the bulk of the material in the appendix.

There is a continuing undertone in all the documents that have described the Public Health Service Drinking Water Standards. This is a social attitude, a desire to require the best quality water that can be supplied nationwide rather than the most miserable water that can be tolerated. There is frequent reiteration of the 1914 philosophy that "water supplies . . . shall be . . . free from offensiveness to the sense of sight, taste, or smell."

Summary

Water quality standards and criteria of appropriate treatment of wastewater may be expected to become more numerous, more re-

strictive, and more detailed as sociological factors, such as the progressively more associated and more complex living of man, put increasing pressure on water quality. The sound standard must be well defined and must seek to promote the integral interests of society. Those concerned with water quality must expect to respond to social pressure and try to mate technology with supply to produce water of progressively better quality at a practical price.

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