Water Quality Issues in Pollutant Trading[1]

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Abstract

As part of implementing the watershed approach for water pollution control, interest is being focused on pollutant trading. The pollutant trading programs that have been developed thus far are based on total chemical constituent concentrations and fail to properly consider that for many chemical constituent sources and types of chemical constituents the total chemical constituent concentration in a source or within the waterbody is a poor measure of potential water quality impacts. Pollutant trading should be based on trading chemical constituents that are adversely impacting the designated beneficial uses of a waterbody, i.e. cause pollution, rather than the total chemical constituent concentrations within the various sources for which trades are being considered.
(KEY TERMS: pollutant trading; point/nonpoint source; water quality criteria/standards; water quality.)

Introduction

Malik *et al.* (1994) have discussed economic aspects of pollutant trading as part of their discussion of economic issues of the watershed approach for water quality management. This discussion, however, fails to consider important often overriding water quality issues that should be addressed in any pollutant trading activity. A fundamental deficiency in most pollutant trading programs that have been proposed is the failure of those involved to recognize the difference between **pollutants** and **chemical constituents**. Basically, Malik *et al.* have discussed chemical constituent trading. It is important in any water quality management program to clearly distinguish between those forms of chemical constituents that are present in a waterbody or its inputs which give rise to a total concentration in the waterbody and those that are present in chemical-specific forms that adversely impact the designated beneficial uses of the waterbody.

Chemical Constituents vs. Pollutants

Chemical constituents exist in aquatic systems in a variety of chemical forms, only some of which are toxic-available (see Lee *et al.*, 1982). For the purposes of this discussion and in accord with traditional approaches, "chemical constituents" are defined as those chemicals which are present in a waterbody or input irrespective of whether they are in chemical forms that adversely impact the designated beneficial uses of the waterbody. "Pollutants," on the other hand, are those chemical constituents that are present in sufficient concentrations of available-

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[1]Submitted for publication in Water Resources Bulletin, February (1996).

toxic forms for a sufficient duration to be adverse to the designated beneficial uses of a waterbody.

The 1972 amendments to the Federal Water Pollution Control Act, PL 92-500, and its subsequent amendments to the Clean Water Act specify that the purpose of water pollution control programs in the US is the protection of designated beneficial uses of waterbodies. All waterbodies have been classified with respect to these uses. They typically include domestic water supply, fish and aquatic life, recreation, agricultural water supply, etc. The goal of water pollution control programs in the US is zero pollutant discharge, not zero chemical constituent discharge. There is no legislative mandate, nor would it be desirable to control all chemical constituent inputs to a waterbody. This would require the discharge of distilled water from regulated sources. Obviously, that would be an inappropriate approach and would be harmful to aquatic life in many waterbodies since aquatic life, domestic water supplies and many other uses require certain chemical constituents in the water to support designated beneficial uses.

Pollutant Trading Approaches

Pollutant trading, therefore, should be based on trading those sources of chemical constituents that actually impair the designated beneficial uses of the waterbody under consideration. For fish and aquatic life-related uses, the pollutants which should be traded are those chemicals in specific forms that are adverse to the numbers, types and characteristics of desirable fish and aquatic life in the waterbody that are of sufficient concern to the public to justify pollutant control. This approach can be and usually is significantly different from chemical constituent trading of the type described by Malik *et al.* where the total concentrations of a chemical are traded, irrespective of the amounts of available-toxic forms present in the input to the waterbody or within the waterbody. Further, the economics of true pollutant trading can be drastically different from chemical constituent trading.

Tietenberg (1992) and Atkinson and Tietenberg (1994) have discussed the concept of "transfer coefficients" in connection with the economics of pollutant trading in the air quality management field. Transfer coefficients relate the concentration of a constituent in a discharge to the concentration at the receptor where the impact of the constituent is of concern. This approach is appropriate when considering near-field vs. far-field impacts in air quality management. However, it does not necessarily address the issue of concern in water quality management, namely that the total concentration of a constituent in a discharge usually bears no relationship to the impact of that constituent, either in the near-field or far-field. The transfer coefficient concept could be expanded to include focusing on pollutants, provided that those responsible for making this evaluation properly consider the difference between chemical constituents in a discharge and pollutants. This, however, to the knowledge of the authors has not been done and was not addressed by Malik *et al.* (1994).

Lee and Jones-Lee (1996a) have recently discussed several implementation aspects of the watershed approach for water quality management, including pollutant trading. They point out that in evaluating pollutant trading it is important to consider both far field - open water

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waterbody-wide impacts of pollutants as well as those that impact designated beneficial uses near the point of discharge, i.e. within or near the mixing zone for the input. Most pollutant trading programs that are now currently being discussed ignore near-field impacts. This could represent a significant error and be strongly detrimental to the beneficial use of a waterbody of concern to a local community that utilizes the waters near the input.

There may be concern about the cost of properly distinguishing between chemical constituents, some of which can be inert and have no impact on water quality, and pollutants. Lee and Jones-Lee (1996b) have recently provided guidance on how to determine whether a constituent in stormwater runoff is adverse to the designated beneficial uses of a waterbody. Such evaluations generally represent a small cost compared to the benefits that would accrue as the result of properly determining whether the chemical constituents in a particular discharge are, in fact, pollutants in the receiving waters for the discharge.

Examples of Inappropriate Pollutant Trading

An example of an inappropriate pollutant trading program would be discharges to a bay or harbor for a large waterbody where fishing, swimming, boating, etc. are extensively practiced within the bay. Therefore, water quality within the bay is of particular importance to the community which utilizes this resource. To trade pollutants between sources that discharge directly and are rapidly mixed into the waterbody overall and therefore have little or no near-field effects of any significance, for pollutants that have significant near-field effects, such as in a bay or harbor, may be technically, and for that matter, politically inappropriate. It is therefore important in conducting any economic analysis of pollutant trading to consider how the true pollutants in each source in which the trading is being discussed actually impact the designated beneficial uses of the waterbody and parts thereof.

Dillon Reservoir

Malik *et al.* (1994) cite what they call pollutant trading as having occurred for the Dillon Reservoir in the Rocky Mountains where the phosphorus loads to the reservoir were traded among point and non-point sources. The authors have considerable familiarity with the Dillon Reservoir eutrophication situation where Horstman *et al.* (1980) found that the Dillon Reservoir behaved like other lakes and reservoirs in the US and other countries with respect to phosphorus load eutrophication response that evolved out of the OECD eutrophication studies. Those studies have been summarized by Jones and Lee (1986). This means that the phosphorus loads to Dillon Reservoir are similar, in terms of the percent available phosphorus, to those that are typically encountered with a mix of point source domestic wastewater phosphorus and land runoff derived phosphorus.

The trading of phosphorus loads among point and non-point sources as practiced at the Dillon Reservoir is an example of an inappropriate approach for trading pollutants. The trading that took place there was not pollutant trading but chemical constituent trading. Those responsible for setting up this trade ignored the vast literature that exists on available forms of phosphorus that are available to stimulate algal growth in various phosphorus sources. Lee *et al.* (1980) on behalf of the International Joint Commission for the Great Lakes reviewed the literature on available forms of phosphorus where they reported that only part of the phosphorus present in point source discharges, such as from POTW's, and from non-point discharges, such as land runoff, are available to affect algal growth in waterbodies. Lee *et al.* (1980) and Lee and Jones (1988) reviewed the information available on available phosphorus in various types of phosphorus sources. For typical land runoff, the available phosphorus is equal to about 0.2 x the particulate phosphorus plus the soluble orthophosphate.

For domestic wastewaters, the available phosphorus in the effluent depends on whether the effluent has been treated for phosphorus removal using alum or iron precipitation. If such treatment has taken place, then the available phosphorus in the effluent could be very low, much below the total phosphorus that is present because much of the phosphorus that leaves the treatment plant is in iron or aluminum phosphate forms which do not support algal growth. Had available phosphorus been used as it should have been to develop pollutant trading for Dillon Reservoir, it could be that a significantly different pollutant trading situation would have developed compared to what was actually done. It is possible that what was done was to trade significant amounts of non-available phosphorus in land runoff for potentially significant amounts of available phosphorus in the POTW discharge.

San Francisco Bay

In the San Francisco Bay region there is considerable discussion about the possibility of trading copper loads from point source discharges for non-point discharge copper. Again, the key issue is how much of the copper that enters San Francisco Bay from a particular source is available-toxic and most importantly in the case of San Francisco Bay, are there any real water quality problems in San Francisco Bay due to the concentrations of copper in the Bay that exceed the overly protective water quality criteria and standards for Bay waters that were developed by the US EPA, the state of California Water Resources Control Board and the San Francisco Regional Water Quality Control Board. It has been found that the concentrations of total recoverable copper and, for that matter, dissolved copper in San Francisco Bay waters exceed the water quality standard adopted for these waters. In accord with current US EPA policy, this situation requires that a wasteload allocation be developed in which the various sources of copper are assigned a TMDL (total maximum daily load). At this time the San Francisco Regional Water Quality Control Board has developed a highly arbitrary set of TMDL's for various point and non-point source discharges-sources of copper for San Francisco Bay. It is estimated that based on current regulatory approaches over $1 billion will have to be spent to try to control copper inputs to San Francisco Bay from urban stormwater runoff sources.

Pollutant trading from various sources of copper has been discussed as a way of minimizing the economic impact of requiring point and non-point source dischargers to reduce their copper loads. Thus far, however, these discussions have focused on total recoverable copper (chemical constituent copper) and as of yet have failed to consider the pollutant copper loads, i.e. those that are having an adverse impact on the beneficial uses of San Francisco Bay waters. This approach is obviously technically invalid since among all of the elements, copper in marine waters is probably the most prone to be present in non-available, non-toxic forms in various sources as well as within the Bay waters. Copper is of potential concern in San Francisco Bay waters because of its potential to be toxic to aquatic life. Numerous studies have shown, however, that the exceedance of the water quality standard for copper that occurs in San Francisco Bay waters is an administrative exceedance that does not reflect any impairment of the designated beneficial uses of these waters. Toxicity tests of Bay waters conducted using the same organisms and organism forms as were originally used to develop the water quality criteria-standard for copper showed no toxicity to this organism (Lee and Jones-Lee, 1995a). Therefore, there is no real water quality problem in San Francisco Bay waters associated with the exceedance of the copper water quality objective. If there is a water column water quality problem due to copper, it will be a near-field problem near the point of discharge. The wasteload allocations and TMDL's are, however, not based on near-field issues but on open water issues.

Independent Applicability Policy

The inappropriate regulatory approach that is being used by the state of California and the US EPA for regulating copper in San Francisco Bay arises out of the US EPA's Independent Applicability Policy (Lee and Jones-Lee, 1995b). This policy mandates that chemical-specific water quality criteria and standards must be achieved, even if toxicity tests or other biological effects-based evaluations show that the chemical-specific standards are overly protective. This is the situation in San Francisco Bay today where the US EPA's Independent Applicability Policy could lead to a waste of over $1 billion in funds devoted to copper control from various sources of copper for San Francisco Bay, yet produce no improvement in the designated beneficial uses of San Francisco Bay waters.

Suggested Approach for Pollutant Trading

Pollutant trading should be based on first finding a real water quality problem. It should not be assumed that because a water quality criterion or standard is exceeded, this exceedance represents an impairment of the designated beneficial uses of the waterbody. The exceedance of a water quality criteria-standard should be used as an indicator of a potential water quality problem in which the discharger(s) is provided the opportunity to determine whether this exceedance represents a significant impairment of the designated beneficial uses of the waterbody. In those instances where a real water quality problem exists, i.e. important uses are impaired, then the specific cause (chemical forms and sources of the chemical forms) is identified. At this point, sufficient information should be available to determine whether the problems are near-field near the point of discharge and/or far-field in the open waters. For those sources that only cause far-field, open water, real water quality problems, it is then possible to begin to develop a technically valid, meaningful pollutant trading program. This program would focus specifically on those sources that contribute those specific chemical forms of the chemical constituent that are responsible for the impairment of the use. It is with this information base that a proper economic evaluation of pollutant trading can be initiated.

Conclusions

It is concluded that pollutant trading is a far more complex process than is typically being considered today. It is essential that if reliable pollutant trades are to be made, that a good understanding of the aquatic chemistry and aquatic toxicology of the suspected pollutants be developed relative to the presence of a real water quality problem in the receiving waters for the pollutant sources. Following this approach can lead to technically valid, cost-effective approaches for managing chemical constituents that cause impairment of the designated beneficial uses of the nation's waters.

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