NATURAL RESOURCES JOURNAL

Volume 12
Issue 3 *Summer 1972*

Summer 1972

Taxation and Water Pollution Control

Terry A. Ferrar

Andrew Whinston

natural resources journal

Published four times a year by The University of New Mexico School of Law

Vol. 12 July 1972 No. 3

TAXATION AND WATER POLLUTION CONTROL†

TERRY A. FERRAR†† and ANDREW WHINSTON†††

In this article we wish to discuss the problem of water quality management. We will examine one of the most strongly advocated methods of administrative control which is suggestively termed "effluent charge" water resource management and carefully discuss the attributes and shortcomings of this technique. Having given due consideration to this well publicized method, we will proceed to describe an alternative water quality management approach and argue for its superiority. In particular, we will discuss a reasonable economic situation where the effluent charge technique breaks down and the method herein described operates efficiently. Moreover, we will argue that this is likely to be the situation found in regions experiencing acute water quality problems.

DETERMINING WATER QUALITY STANDARDS

Let us suppose that as the result of public pressure to "save our water" the region's governing structure assumes the responsibility of water quality control.[1] In an attempt to insulate the control of the region's water resource from the pressures of party politics the governing body sets up a Water Control Board (W.C.B.). This W.C.B. will have the legislative and judicial responsibility of specifying a standard for water quality and enforcing this standard in the region's watercourses.

The W.C.B. will immediately recognize that there is no universally accepted measure of water quality. In the study of water quality

†This research was partially supported by a Public Health Service grant #1 F03 AP48007-01, from the National Air Pollution Control administration; and by the Office of Water Resources Research under contract #14-31-0001-3080. The opinions presented are the responsibility of the authors.

††Assistant Professor of Economics, Pennsylvania State University; Research Associate to the Center for Air Environment Studies.

†††Professor of Economics and Management, Purdue University.

1. For generality of exposition we need not refer to the relevant governing structure as federal, state or one of the various forms of local government; but it is one of these to which we are referring.

problems one discovers talk of "suspended solids," "BOD," and "pesticide residues," as well as other types of water quality measures.

But the W.C.B. has the mandate, presented to it fundamentally by the region's population, to "do something about the region's water quality." So let us suppose as a first approximation the W.C.B. decides on a quality measure or a combination of measures to serve as a "yardstick" for its operation.

The second order of legislative business to be conducted by the W.C.B. must be to determine the required level of water purity in the various watercourses of the community. Through consultation with hydrologists the commission members must determine the assimilative capacity in the various reaches of the involved streams and through demographic studies of the concerned public they must determine the effect on the population of alternative levels of water purity. With this information gathered the W.C.B. must make the unenviable reach-by-reach, stream-by-stream specification of the required level of water quality. The final legislative act of the W.C.B. will consist of a public policy announcement of the required water quality profiles in the region's water-courses.

At this point the W.C.B. may justly feel that it has come a long way in the struggle for water quality control. The remaining task faced by the W.C.B. is that of enforcement of the now enunciated water quality standards. To this we turn in the following sections where we examine alternative approaches to the administrative problem. Both of these managerial techniques take as the goal of the W.C.B. the satisfaction of these water quality profiles at minimum total direct cost. In this sense, the W.C.B. desires to induce pollution abatement activity to the required level in a manner that minimizes the sum of the individual abatement costs.

EFFLUENT CHARGE SCHEMES

By far the most famous administrative technique to induce pollution abatement activities is that of effluent related taxation schemes. A leading proponent of this technique is Allen Kneese [1] who argues for the efficiency and minimal information demands of such methods.[2]

The argument is frequently made that the use of watercourses to dispose of waste material is a good that is being used up by polluters and should be priced as any other good. The price is called the "effluent charge." Setting water quality standards in effect fixes the amount of watercourse disposal capacity for sale, and the equilib-

2. Hass, *Optimal Taxing for the Abatement of Water Pollution*, 6 Water Resources Research (1970).

rium effluent charge is defined such that the demand for watercourse disposal capacity is equal to this fixed supply.

There are several pleasant features about this technique. First, it satisfies our criterion of minimum total abatement cost while maintaining the specified water quality profiles. Since each polluter decides for himself by how much, if at all, he should reduce his wastes, the burden of pollution control is thus shared in exactly the right way. That is, since every polluter adjusts to the charges in whatever way minimizes *his* cost, the social cost of achieving the target amount of waste discharge—which is the sum of the costs borne by all polluters—will also be minimized.[3] In economic terms each polluter equates his marginal cost of pollution control to the prevailing effluent charge which is just large enough to induce the required abatement activity.

Second, since the effluent charges are actually collected from those who do pollute the W.C.B. is supplied with an economic rent on the region's natural watercourse disposal capacity. This revenue factor is understandably attractive to those familiar with government financial problems.

Third, it is relatively easy to operate. By measurement of waste outfalls the correct individual tax payment is assessable.

Fourth, the effluent charges give the correct incentives to the polluters. A polluter may reduce his costs by discovering alternate products, processes or abatement techniques.

We now turn our discussion of effluent charge administrative schemes to those features of the method which are of the undesirable nature. The most detrimental objection we would like to raise to this type approach to water quality management concerns its fundamentally static applicability. In a nondynamic, nongrowth oriented region it is reasonable to assume that some semblance of an equilibrium effluent charge rate could eventually be established to provide the required inducement for abatement in the region. However, as is surely apparent to the reader, our most acute water quality problems occur in the most vigorously developing metropolitan regions of our country. In this more dynamic setting the concept of a static equilibrium effluent charge is meaningless. Moreover, to expect the W.C.B. to maintain a dynamic equilibrium in response to changing watercourse disposal demand is clearly unreasonable. The problem is the advocates of effluent charge water quality management are trying to superimpose a technique that has validity in a static situation on a highly dynamic phenomenon.

Another problem intrinsic to the effluent charge schemes is the

3. J. Dales, Optimal Taxing for the Abatement of Water Pollution (1968).

indiscriminate nature of any imposed tax scheme. With an ordinary good there is no justification for refusing to pay a price. But the case of watercourse waste disposal activity is somewhat different since originally this waste discharge acti- ity was not priced. The good was available and served as an inducement for industries to locate. Implicitly a right was given to use whatever environmental waste disposal capacity that was available. With effluent charges there is no cognizance of these prior rights.

ALLOCATION OF ENVIRONMENTAL PROPERTY RIGHTS

We propose an approach to the administrative problem faced by the W.C.B. that is superior to the effluent charge techniques, whose properties were discussed above. We believe that all the desirable properties of the effluent charge method are carried over while the disturbing features of that method are omitted by our managerial scheme.

Within the effluent charge framework the allocation of the available waste disposal capacity in the region is handled implicitly via a taxation inducement on the behavior of the polluters. We argue that it is the concealment of the basic availability of disposal capacity that produces the failure of this technique in a dynamic situation. Moreover, we will discuss the direct allocation of watercourse disposal capacity to the polluters and demonstrate that the dynamic failure so apparent in the effluent charge schemes is resolved via this approach.

Let us assume that through consultation with hydrologists the W.C.B. members may determine the effect from each major waste outfall on the various reaches of the stream. That is, the W.C.B. may determine the effect of any given waste discharge on all downstream reaches in terms of the accepted water quality measure. Now the W.C.B. may correctly view the determined water purity standards as a lower bound on the region's water quality. Therefore, with the use of the assumed diffusion relations the W.C.B. may conveniently convert these lower bound purity standards to upper limits on waste outfall levels. With this conversion we may appropriately discuss the responsibility of the W.C.B. as:

> The allocation to the community's polluters of the available or legal watercourse rights for waste disposal according to the cost minimization criterion.

It is in this sense that our administrative technique involves the direct allocation of environmental property rights or user permits among the potential polluters of the watercourse. Moreover, since the supply of such user permits is fixed by the determined water quality standards any allocation mechanism consistent with this supply will never permit the violation of these standards. As such we will observe that the dynamic allocation technique to be described will maintain these water purity specifications.

THE ALLOCATION MECHANISM

The method herein described involves an incentive-feedback algorithm that iteratively allocates the available environmental resources among the polluters in accordance with the cost minimization criterion of the W.C.B. Starting from an initial division of the available environmental disposal capacity among the polluters of the community, each iterative reallocation more closely approximates the optimal apportionment under the given criterion. Let us suggest that dividing the available environmental resource among the polluters of the community in proportion to the historical allocation would serve as a suitable starting point for our algorithm; this will give some recognition to the existing industry structure and help alleviate the arbitrary nature that was discussed previously as an intrinsic part of the effluent charge schemes.

The question then is how to reallocate these available environmental property rights among the polluters in a manner consistent with the W.C.B.'s goal function. Now for each apportionment among the polluters we will show that each polluter can evaluate the effect on the W.C.B.'s cost criterion of obtaining a slightly larger water resource property right allocation. The polluter that indicates that it can achieve the greatest positive effect on the W.C.B.'s criterion value for a unit increase in property right allocation is favored in the succeeding allocation by the W.C.B.

We are effectively describing a bidding operation for property rights between the polluters and the W.C.B. Thus, this iterative procedure successively reapportions the total available property right allotment for waste disposal among the high bidders of the community. Moreover, this bidding operation results (as would be anticipated) in prices for exchange in this property right market. In this light, the initial or historically derived allocation is successively adapted to the optimal allocation as implied by the W.C.B.'s cost criterion, but at no time in the adaptation process are the environmental quality standards violated—the total available supply is fixed.

In the following section we will develop precisely the bidding system alluded to here, and we will carefully consider the role of the W.C.B. in guiding the system to the optimal allocation.

DISCUSSION OF THE ALLOCATION MECHANISM

We must first examine the assertion that each polluter is capable of evaluating the effect on the W.C.B.'s allocation criterion associated with his obtaining a slightly larger water resource use right allotment.

In this area consider the effect on the polluter of a marginal increase in his water use permit allotment. This increased supply of waste disposal resource will permit a reduction in the scale of his waste treatment effort. That is, associated with a marginal increase in environmental property right allotment the polluter will experience a marginal cost reduction in his pollution control activity. We now recall that the W.C.B.'s optimality criterion consists of the summed pollution control cost outlays of all the polluters, and it now becomes apparent that each polluter can evaluate the marginal effect on the W.C.B.'s criterion associated with a marginal increase in his water resource allotment. That is, the marginal cost reduction in each polluter's waste treatment activity associated with a marginal increase in water resource property right allotment is precisely the marginal effect on the W.C.B.'s criterion associated with such an allocation change.

With this capability of the polluters established let us observe one difficulty in the allocation method alluded to above. Even with the reasonable assumption that the local waste treatment projects all exhibit decreasing returns to scale it is still unclear what we mean by "favored in the succeeding allocation." Since the marginal cost exhibited by each polluter is *related to* his present water resource allotment the appropriate degree of "favoring" to take place is unspecifiable. It is this snag in the above reasoning that demands the construction of an iterative process by which the W.C.B. may become "sensitized" to the various waste treatment cost functions. In particular, the two-way information transfer which will constitute an iteration of our algorithm will successively permit the W.C.B. to "learn" the necessary cost characteristics associated with each polluter. We will now begin the description of the algorithm in a manner by which this learning process will become apparent.

Starting from any initial allocation of the available property rights the W.C.B. will request the following information from the region's polluters:

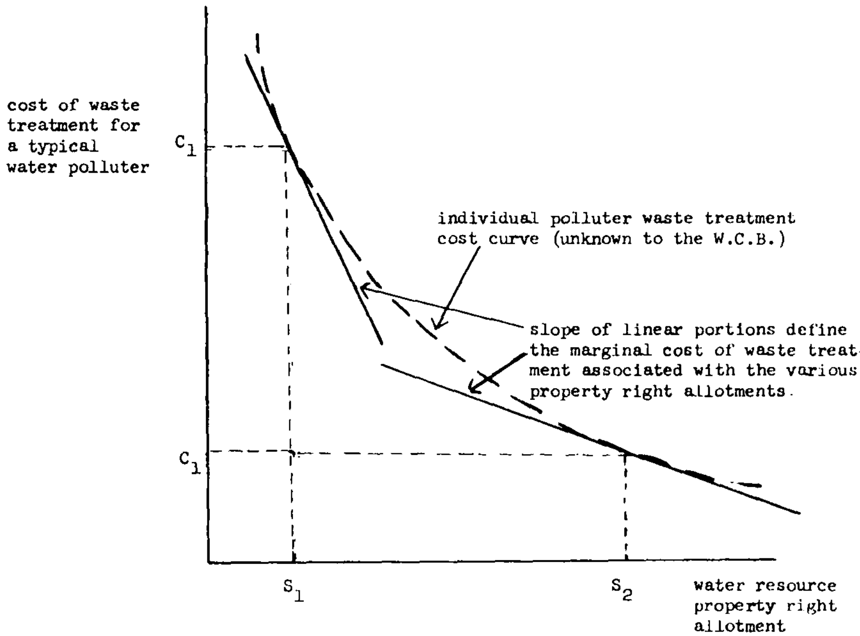
1. The marginal cost of waste treatment associated with the present scale of operation.

2. The total cost of the waste treatment activity presently undertaken.

Maintaining our supposition that the waste treatment projects exhibit decreasing returns to scale we may portray the W.C.B.'s "cost curve learning process" as in Figure 1. In this figure the dotted cost curve is unknown to the W.C.B.'s commissioners, but the tangential portions may be constructed from the information obtained during each iteration of the algorithm. This construction follows directly from the fact that the slope of the waste treatment cost curve is precisely the marginal cost of waste treatment which in turn is associated with the allocated level of user permits to the polluter. In this manner the W.C.B. may successively (iteratively) investigate the waste treatment cost considerations of the various polluters.

We now assert that by careful consideration of such piecewise-linear approximations to the polluters' cost curves the W.C.B. may iteratively approach the region-wide cost minimizing allocation.[4] In

Figure 1.



S_t ≡ property right allotment in period t.

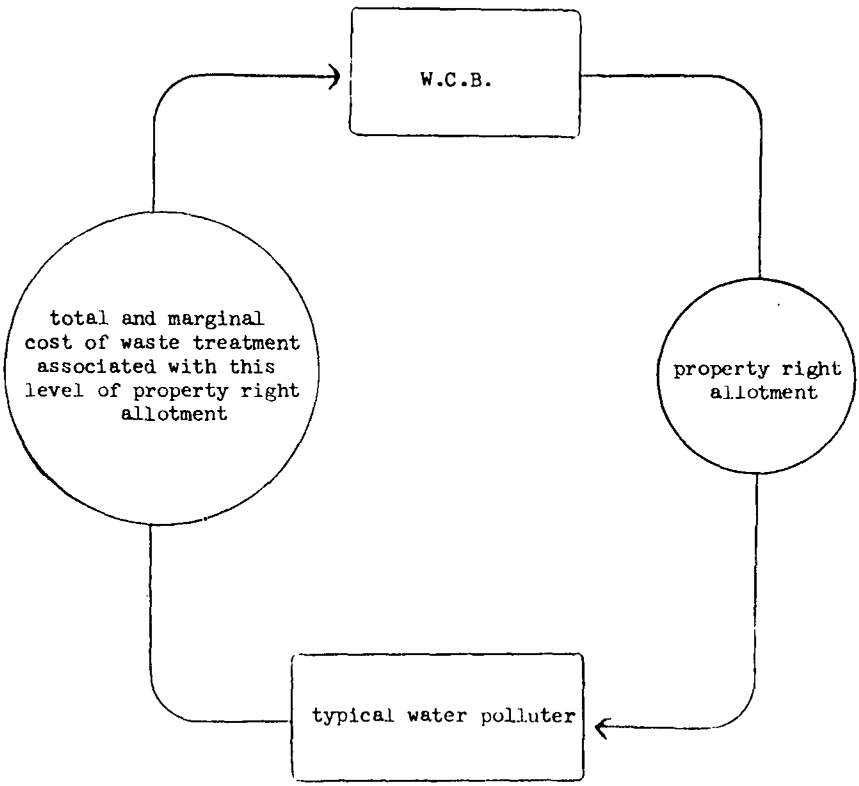
C_t ≡ cost of waste treatment in period t.

4. For a detailed proof of this result *see* T. Ferrar and A. Whinston, Environmental Resource Allocation (1971) (an unpublished manuscript, where the tools of optimization theory are exploited to analyze this technique).

particular while recognizing the fixed supply of property rights in the region, the W.C.B. in each time period must determine a desirable allocation (*i.e.* the W.C.B. must reshuffle the supply of user permits among the polluters); this allocation will induce a polluter response (information sets 1. and 2.) which will serve to increase the degree of understanding of each polluter's cost structure. This improved understanding will serve to permit an improved reallocation in the following period. Hence, we will observe a dynamic convergence to a cost minimizing allocation of the property rights available under the previously specified water quality standards.

We have described a communication based algorithm by which the W.C.B. may infer sufficient information to guide the system to an optimal allocation of the available property rights. We may portray the communication linkage for this dynamic (iterative) allocation method as in Figure 2.

Figure 2.



Portrayal of the communication linkage in a typical iteration of the allocation algorithm.

COMPARISONS

Let us re-examine the two allocation methods discussed in this work with the hope of establishing a fundamental distinguished feature. This can best be done by examining the repercussions created by the entrance in the region of a new potential polluter.

If this form of economic growth was to occur in a region whose water purity were protected by an effluent charge type scheme we would likely observe the following chronological pattern:

a. The new polluter, observing the existing effluent charge, would begin disposing at his optimal rate into the watercourse.
b. This added waste load on the stream would deteriorate the water quality below the previously specified standard.
c. This watercourse deterioration would signal the W.C.B. that a change in the equilibrium level of the effluent charge had occurred.
d. The W.C.B. would increase the effluent charge to the point that would restore the desired water purity.

Turning now to the analogous chronological account that we would observe in a region whose water purity was protected by a property right allocation scheme, we would have:

a. Since any waste discharge must be preceded by the granting of waste disposal property rights, the new potential polluter would take the initiative and request to enter the bid-allotment process operated by the W.C.B.
b. Through the described bid-response mechanism the W.C.B. would reallocate the available water use permits among the polluters of the region.
c. After obtaining his allotment of property rights the new polluter may begin operation.

Since a given set of water quality standards imply a maximum effluent discharge profile in the watercourse, the entrance of a new polluter will result, via either scheme, in an adjustment of the outfall profile in the region. However, the fundamental distinguishing feature is the temporal relation of this outfall profile adjustment and the initial waste discharge by the new polluter. In the effluent charge scheme the waste dumping and water quality deterioration *preceded* any action by the W.C.B.; however, in the property right constrained scheme the W.C.B.'s reshuffling of available rights preceded any new waste discharge activity.

It is apparent that the property right allocation scheme places the burden of adjustment on the new potential polluter whereas the effluent charge scheme sacrifices the environmental quality during the adjustment period. Moreover, in a dynamic expanding community it is not unreasonable to anticipate the existence of a perpetual adjustment lag which under the effluent charge scheme would imply the perpetual violation of the water quality standards.

CONCLUSION

By placing some economic interpretations on the above formulation, we may manifest the desire of polluters to encourage the optimal allocation of the available environmental property rights by the W.C.B. Let us, as the W.C.B., inform the polluters that they may alter their allotment by bidding on a per unit property right basis for additional rights. However, as part of the rules of the game the polluter will be required to pay this per unit charge on every unit of property right allocation to him in the following period. The bid we would receive from each polluter would be equal to the marginal cost of waste treatment necessitated by the present property right allotment–that is, the highest price they can justify paying.[5] But, this is precisely the information required by our algorithm; hence, this bidding framework is a reasonable manner of eliciting thy necessary information from the polluters. Moreover, since suboptimal allocations will necessarily result in some polluters' being subjected to an excess demand or supply of property rights at the prevailing price, we will have a concerted effort to encourage the bidding-reallocation process. All polluters will be at equilibrium (in the sense that excess demand is zero) only when the allocation by the W.C.B. is optimal.

Notice also by charging the polluters according to the above bid-allotment process the W.C.B. will obtain revenue support for its operation. Hence, by instituting the above modification of the property right allocation scheme we are able to recoup one of the more attractive features of the effluent charge techniques.

We would like to make one final observation concerning the relative merits of the Dales' market allocation framework and the one presented here. In light of the burden associated with suboptimal allocations, as discussed above, considerations as to the speed of adjustment seem of central importance when considering the relative merits of alternative systems. The Walrasian adjustment mechanism suggested by Dales can best be characterized as a marginal price adjusting system whose speed of adjustment depends critically on the efficiency of information transfer within the market; however, the complexity of the information involved in such a property rights

5. Implicit in this discussion is some assumption about the bidding behavior of the polluters, and we are ignoring the possibility of gaming (false bidding).

market, involving technical as well as sociological problems, would tend to inhibit the effective communication among the participants. In particular, it is felt that the information demanded by our mechanism, though slightly greater, is more easily obtainable due to the more centralized coordination and permits a relatively aggressive approach to the optimal allocation.