Chapter 3
Water and Economy

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Abstract This paper addresses one of the important issues that face water against its economic aspects: the use of economic instruments to manage water resources. First, historic and conceptual issues are considered. In a second part, the Brazilian water resource legislation is analyzed. In a third part, the water user pays principles (UPP) and water polluter pays principles (PPP) are considered, with their contributions towards adoption of economic instruments for water resources management. Finally, a comparison between these principles and the reality of the current Brazilian water resources management is presented, showing that there is still much to move.

Keywords Benefit-cost analysis • Cost-effectiveness analysis • Polluter pays principle • User pays principle • Water charges • Water resources management

Introduction

This article addresses one aspect of the vast subject of "water x economy" namely: up to what point are the multiple uses of freshwater, and especially the discharge of effluents into our watersheds, affecting the economic value and the prices of this natural resource, which up until a few decades ago, was considered a "free good" or a "good of free access" for its several uses such as: a productive input, to dilute and

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assimilate effluents, supplier of the so-called environmental amenities.[1] Today, the situation is totally different.

The understanding of this phenomenon is immediate if we pay attention to the data collected and worked upon by Williamson and Milner (1991), who supplies us with an enlightening historical overview. According to the authors, in the 200 years of Industrial Revolution up until 1990, the planet's population practically increases by six times (going from one to six billion inhabitants), while the Gross World Product, except for the issue of index numbers, was multiplied by approximately 33 times. This last data represents, in average, a doubling of population every 40 years. Taking into consideration the property of geometric progression of ration by 2, in which the last term of the progression is greater than the sum of the preceding, in turn implies that, in estimated terms, during the period of 1990–2030, the planet will experience a pressure in terms of: use of space, use of natural resources and discharge of effluents—greater than that of the previous 200 year.

This phenomenon of exponential growth—typical since the Industrial Revolution, but absolutely new to the History of the Planet—is at the core of Boulding (1966) Seminal paper on the economy of the cowboy versus the economy of the spaceship: we are no longer in the time of the economy of the great plains and of the abundance of natural resources; the natural environment of the economic system is no longer an unlimited reserve of raw materials and environmental amenities, nor is it a septic tank in which we can simply dump and recycle all the debris at no cost. In addition, one needs to understand that the problems of stress and environmental degradation are not a result, in itself, of the use of natural resources and of the waste emission by humans, for such use and emission have always occurred. The problems results in fact from the volume, with regards to nature's capacity to sustain and assimilate the increased quantity of emissions: environment has become scarce and needs to be "economized". And, similar to what occurred with fertile lands—the first natural resource to become relatively scarce to needs—the natural assets will follow the same pattern, in an increased fashion, at a price based on scarcity. To make matters worse—actually perfectly understandable based on the exponential growth of population of production and of problems, as Mckinney et al. (2007) indicate—we are no longer experiencing a "local" degradation of our rivers and of our metropolitan air caps, we are in fact at a level where the problems deriving from over exploitation and pollution of natural assets have reached a global scale: compromising of the ozone layer, global warming and climatic change, decrease of biodiversity and of forest areas. In the majority of the advanced countries, especially in Western Europe, the management of the water resources is being made within the trend which became known as publicizing of water. This phenomena[2] is part of a greater context of tendencies of environmental policies which are characterized by three main components: (1) a strong and growing intervention by governments, featuring an environmental ownership by the states; (2) diversification of policy instruments, increasingly using among others, two economic

[1] For a comprehensive review of issues related to waters, see Rebouças et al. (1999) and Tundisi (2003).

[2] The exposure is also true with regards to the administration of air pollution.

instruments, that of charging for use (the so called User Payer Principle—UPP) and the tradable pollution permits; and (3) implementation of environmental policy, in general within an analytical framework called Cost Effectiveness Analysis, which aims to achieve quality goals of receiving waters, an objective almost always socially agreed upon at the lowest cost to society as a whole.

The Environmental Policy outlined above is the culmination of a process which lasts over one hundred years and started with court disputes at the end of the nineteenth century and the first half of the twentieth century, going through the famous Command and Control Policy, since the end of World War II and in effect, exclusively, until the end of the 1970s.[3]

Charging for the Use of Water

When it comes to charging for the use of water, it is common to hear the allegation that water is already paid for by the consumer. The answer to this objection will lead to the conceptualization of four prices of water. In a typical large city, an urban consumer pays two prices for the drinking water he consumes:

1. The price corresponding to abstraction service, treatment for purifying plants and distribution of treated water to the consumer.
2. Price corresponding to the sewage service, that is, the collection of sewage from the consumer, transportation and final destination of the used water to the bodies of water.

In this procedure, the water body—weather it's a source of resource or a cesspool of waste—is accessible to all, and free of charge. In the early days of development and of urbanization, with a low per capita income and low population density, these two prices for water were perfectly functional, covering the costs society had with regards to the provision of water supply and sanitation. Gratuity of water in nature was possible because it was abundant in relation to needs; all other uses (hygiene, fishing, navigation, irrigated agriculture, etc.) were viable, not being influenced by urban use, since the capacity of the water bodies and their assimilation ability for all the uses was sufficient, at no cost.

However, as economic development, increase of income per capita as well as population growth occurred, the need for feeding the population through intensified irrigated agriculture, through the making of a series of consumer products for the modern society, and the need for transportation of these products etc., was also generated. In the starting phase of this process of economic growth, as the discharge of sewage back into the bodies of water exceeded its capacity of self-purification, it caused such a severe degradation in the quality of water that it compromised balneability, fishing and even the supply of drinking water which then became more expensive due to the increase of treatment costs. At a later phase, as the removal of

[3] For a comprehensive review on this progression, see Lustosa et al. (2003).

water became excessive in relation to the carrying capacity of the water bodies, it generated problems related to quantity, made evident by sudden conflicts over the use of water. Anyway, the fact is that the bodies of water in the vicinities of the large development centers have become scarce, both with regards to being of insufficient quantity as well as for its degraded quality; and all of its uses, with free access to everyone at no cost, is no longer possible.

It is in this situation of being at the limit that society can opt for governmental intervention, establishing state ownership of the resource, which then ceases to be of free access—with the objective of rationing and streamlining its uses. On the other hand, a system of allocation of quotas or the granting of rights to uses of water can be implemented, as a way of normatively reconciling the availabilities with the uses of water.

This is a management tool incorporated to the so-called command-and-control class.

On the other hand, the User Pays Principle can also be implemented as an economic tool to promote the rationing and the streamlining of use, aiming at the same conciliation among availability and use of water, by means of economic incentives, implying in two additional costs for water:

3. Price corresponding to the abstraction and consumption of water, aiming at rationalizing consumption, enabling even investments in sparing devices or in devices which increase water availability.
4. Price corresponding to discharge of sewage in rivers (the most famous being the Polluter Payer Principle), also in a sense of slowing its launching[4] and enabling investments in treatment plants for example.

The payment of prices 1 and 2 are not a novelty in the Brazilian scenario. One pays the concessionaries of water supply and sanitation for their services and one pays for the water supplied in irrigated perimeters. In all cases, once seeks to maintain the financial health of concessionaries so that they can deal with the costs of providing the services and deal with the costs of expanding their services in order to meet the growing demands.

Prices number 3 and 4, are in fact a novelty brought about by the modern policies of water resource management and integrate the so-called User Payer Principle (UPP), becoming an increasingly used instrument in a sense of enabling the several uses of the bodies of water which have become scarce. These prices are the main conceptual framework of the billing system for uses of water, to which this article refers to.

Brazilian Legislation of Water Resources

The trend of publicizing water echoed within our country, culminating in the enactment of the Federal Constitution of 1988, in which state ownership of water was established (art. 20, I and art 26, III, waters as assets of the Union or of the federated units). Based on this, several states of the federation progressed in a notable way, as

[4] If the tariff per unit discharge is sufficiently high, it will cost less for the agent to treat the sizeable portion of the sewage and pay for the residual pollution, than to pay for the total discharge of the generated sewage.

they enacted their State Constitutions and the respective laws regarding the management of waters under their domain, to incorporate in the management policies, the use of billing for the water resources (see, especially the laws of Sao Paulo—Law 7,763/91 and the law of Rio Grande do Sul—Law 10,350/94). Finally, Federal Law 9,433/97, giving shelter to these pioneering laws, also incorporated billing as an important tool in the management of waters. Federal Law 9,984/2000 (National Water Agency—ANA) is, undoubtedly an essential complement to Law 9,433.

The system proposed for Brazil, within these laws, places the country in the path of implementing a cost-effective policy, partially inspired by the German experience of the Water Companies of the beginning of the twentieth century and by the French system of basin committees/agencies, nationally established as of 1964. The French water resources management system is a decentralized and participatory model, that operates through the committees of water basins; true "water parliaments" responsible for managing the waters of the respective basins within a condominium perspective with the technical support of the basin agencies.

In the legislation being implemented, we clearly distinguish through the classification of bodies of water into categories of quality with regards to how they are expected to be used, the establishment of standards of quality with goals determined by environmental authorities and expressed by society, which need to be gradually achieved by the respective basin committees. In order to achieve this, the committees need to use several management tools, among them: (1) Basin Plans—planning tools for the interventions required to achieve the goals; (2) Guidelines for Licensing—aiming to reconcile the several uses of water in the basin; and (3) Charging for the use of Water Resources (the so-called User Payer Principle—UPP)—an excellent economic instrument, which aims at inducing a more moderate and rational use of water resources and at financing the necessary interventions foreseen in the basin plan.

In 2002, the country began charging for the use of water. This first implementation of the User Payer Principle occurred in the basin of the Paraiba do Sul River (where the main river, for which the basin is named after, is of federal domain) through the Committee for the Integration of the Paraiba do Sul Water Basin. In 2006, the PCJ Committee started charging for the use of water in the Piracicaba, Jundiaí and Capivari rivers. It is important to note that the Brazilian experience, with regards to pollution, differs from the French model which inspired it—since the charging is currently based on the components of the organic load only (the Biochemical Oxygen Demand—BOD). The non-organic load and the so-called "toxic-load" (heavy metals, etc.) will probably still be dealt with for some time, through the emission standards (Command and Control Policy).

The User Payer Principle (UPP)

Within the framework of a cost-effective Environmental Policy in the area of water resources, the charging for the use of water, as an instrument of incentive, almost always prevails: the so-called User Payer Principle (UPP). UPP encompasses the charging for abstraction of water from the source (which does not have a proper name), for the consumption[5] and the billing for the discharge of effluents (the "old" Polluter Payer Principle—PPP).

Billing for Water Abstraction

In order to maintain the discussion within its essential aspects, we will examine a hypothetical case with only two groups of users. Let's consider the case of an area which has its agricultural (irrigation) and urban supply made possible by a stretch of the river that runs through the region. Figure 3.1a shows the demand for raw water, per period (i.e. monthly), of the agricultural sector for irrigation purposes (Da). Figure 3.1b shows the demand for the same period, of the Water Supply Company for purifying plants and distribution to urban residents (Du).

If the available flow rate during the period, for supply and irrigation, is superior to the sum of Q1 + Q2, the abstraction for this period will correspond to this sum, in which the abstraction will be free of charge for both groups of users. Makes sense, if there is a relative abundance of the water resource, there is no reason to restrict demand by imposing a cost for the abstraction of the raw water.

Yet, if the available flow rate during the period is inferior to the sum of Q1 + Q2, the maximizing of the Total Net Social Benefit (area above the demand curve) requires that the consumption of both groups be contained up until the point where the Marginal Net Social Benefit is equal to both consumers. This can be obtained through the charging of a price (specifically the charging for water abstraction) equal to TT′ in Fig. 3.2, where the curves of the Total Net Social Benefit of both consumers are placed one against the other, in comparison to the fixed limited availability (periodic availability flow) of raw water by the river. As can be seen on the graph, any point of consumption other than AT, for agricultural consumers (irrigators) and GT, for urban consumers, results in a Total Net Social Benefit inferior to the maximum, in view of the fact that the marginal benefic achieved by any group that increases its consumption is inferior to the marginal benefit lost by the other group.

We can make two observations. First, Fig. 3.2 serves to explain the seasonality of billing for water abstraction, even in contemporary situations. What happens is, in certain regions, during rain periods, the river can be considered to be abundant with regards to the total demand, and therefore, configures in a situation where there is no need for billing for water abstraction to slow down consumption. Billing for abstraction is only applicable in drought periods, when there is indeed a situation as depicted in Fig. 3.2. Secondly, the type of analysis performed above is identically applicable to the cases of subterranean waters, in other words, in the event that the

[5] This is why, many times, the term User Payer Principle is used to designate a billing for abstraction and consumption of water. Nevertheless, to us it seems more appropriate to maintain the allocation of UPP to encompass abstraction, consumption and the discharge in effluents, because the user of a water resource is both he who abstracts and consumes, as well as he who discharges into effluents.

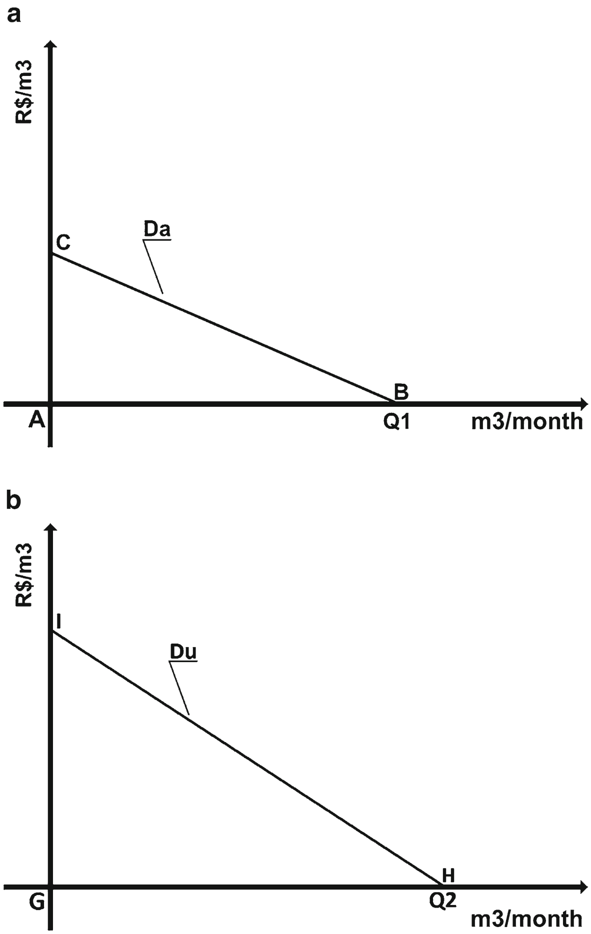

Fig. 3.1 Billing for water abstraction

total demands, supplied by abstraction, is inferior to the recharge of aquifers, there is no need to bill for anything; in the opposite case, charging would be justifiable.

Some practical observations are necessary. For the implementation of the efficiency criteria described above, evidently one needs to have the water demand curves for each sector involved. These water demand curves depend on the determination of a "production function" for the water, in other words, a function which associates the several quantities of raw water abstracted to the production of the sector. Once this is established, it is possible to, via optimization of microeconomic analysis, determine the quantities of water each sector will abstract and the several possible prices.

The pure and simple implementation of the efficiency criteria can lead to deadlock situations, where for example, the demand of a group can be so high (the demand of the supply company for example) with regards to another group

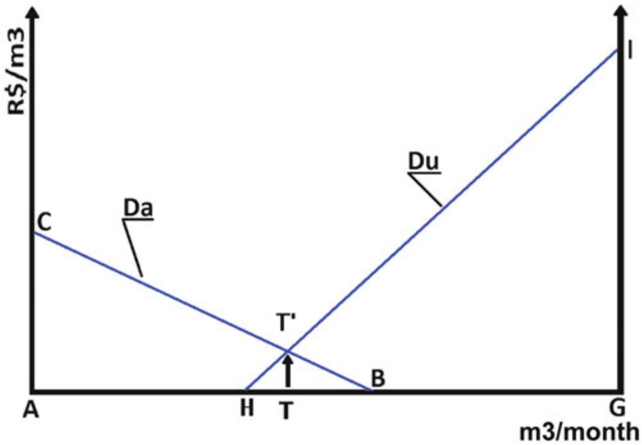

Fig. 3.2 Seasonality of billing for water abstraction

(hypothetically let's say the irrigators), that the determination of an efficient price, would lead to the impracticability of one of the sectors for being so elevated. Thus, rarely are production functions and demands for water for all sectors calculated, instead, one chooses to use prices determined by approximation/negotiation. These prices are generally agreed upon, in order to partially or totally fund the interventions within the basin destined to increase the use of water or better utilize it (flow regulating dams, canals, etc.).[6]

However, for planning purposes by a centralized authority or for the purposes of negotiation at a basin committee level, it is essential to at least count on the demand function of the agricultural sector (irrigators), due to the level of consumption of the sector, as well as its economical importance.[7] A demand curve of the agricultural sector calculated at a reasonable approximation can demonstrate the level of subsidy needed for the sector, as well as the level of coverage of the financing of the necessary construction for the implementation of the irrigation (it would be most convenient if the tariffs could cover at least the operational and maintenance costs, partially contributing to the capital costs).

The imposition of a price for the companies that supply treated water, charging for abstraction of raw water, raises a relevant issue. As the charges for use is passed on to the urban consumers, in the final tariff (and this would need to be done…) the water company may face problems with regards to profit. In reality, although the company is a natural monopoly, it is not free from facing, on behalf of the consumer, a variation in the price of demand. If this variation is equal or greater to one, the company may, after passing on the billing, experience a decrease in income, for

[6] A more ample and profound review, including the issue of billing for discharge in effluents can be found in Hartmann (2008).

[7] The classic reference with regards to the demand of water for irrigation is James and Lee (1971).

a similar production of something smaller. Given its cost structure, where fixed prices predominate, this could compromise its profitability.[8]

The Billing for Discharge of Effluents (PPP)

In Fig. 3.3, the segment Od represents, in terms of percentages, the total of emissions/year of a given polluter (BOD for example) at present, in a given watercourse. Through hypothesis, the use of the so called dispersion models allows us to establish that, in order to achieve the level of quality established at the time of the framework, it is necessary to annually eliminate the percentage of Oc. Seeing that, in the beginning of the process, a goal of such nature would be very ambitious, it is broken down into several partial goals to gradually be achieved in successive periods of 4 or 5 years. Thus, we would have as an example, the goal Oa to be achieved in 5 years, Ob in 10 years and finally, Oc in 15. Once the abatement cost curve is drawn (long-run marginal cost), CMg—that organizes in a growing manner, the cost of abatement of the several polluting sectors[9]—it is possible to, through successive and growing tariffs over time, achieve the established goals. Thus, the tariff of OT1 $ton-year allows for the abatement of the proportion Oa and, thereby achieve the first partial

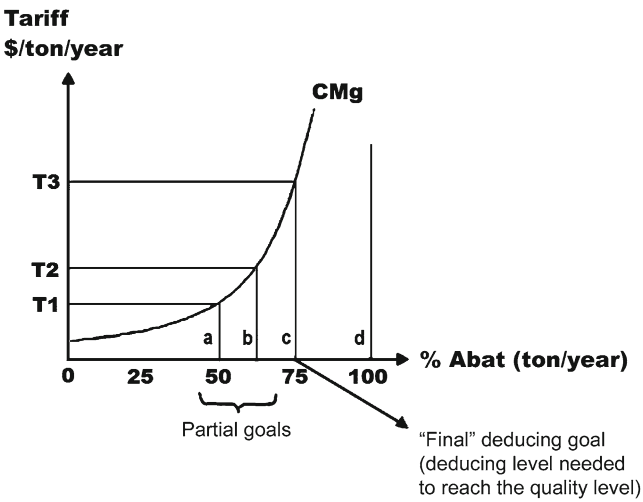

Fig. 3.3 The PPP in the context of a cost-effective policy to combat pollution

[8] Obviously, these effects will occur when the price charged becomes significant enough to result in a deduction in use of water; at this moment, Brazilian experiences have not reached this level.

[9] Such curve is construed by the basin's agency, based on information on abatement technologies commercially available (in general, end-of-pipe).

goal. Actually, given this tariff, all polluter agents whose pollution abatement cost is inferior to the tariff (part Oa of the CMg curve) will prefer to abate pollution rather than discharge and, therefore pay the tariff. Other polluters however, such as those on part ad, whose abatement cost is superior to the tariff, will opt for paying the price OT1 and continue to pour their effluents. Upon the conclusion of this "program" (which in general takes a few years), one can carry on to a second phase, using a higher tariff OT2. In this case, it will now be those in category Oa, who will prefer to abate (in addition to those in Oa who will evidently continue to abate), while those in category Bd will pay a higher price, but even so, will not yet treat their effluents; and successively until the ultimate goal is achieved.

The description above illustrates the incentive aspect of charging for the use of the resource. In reality, rising prices induce; they urge the user agents to "moderate" their uses until desired levels are achieved. But, they also serve to illustrate the additional aspect of the potential funding for rebates to be made. Looking into the case of the first phase mentioned above: the use of the tariff of OT1 $/ton-year. The "payers" of part ad, who produce an income OY1 x ad, enable the committees/agencies to contribute the financial resources (or at least part of it) so that the "abaters" of part Oa can perform the necessary investments to the respective abatements. The same logic is applicable to the subsequent phases.

In the decentralized and participatory system being implemented in Brazil, this aspect of a financing tool allocated to the tariff is very clear. And more, the committees, as true "parliament of the waters" as they are, will possess jurisdiction to decide on which type of financing should be granted, weather at market interest rates, at subsidized interest rates or at no cost. It is not an exaggeration to say that the conjunction of these two aspects, that of an incentive tool and that of financing, available to an agency representing society (the committee) represents an important promise with regards to the recovery of the quality and the quantity of our watercourses, providing an effective possibility of reconciling economic growth with the protection of one of the most essential natural resources, known to be one of the most complex "trade-offs" of contemporary economy.

This cost-effective approach raises theoretical-practical issues of extreme importance that can be better assessed when analyzed through a practical implementation such as the one found in Cánepa et al. (1997). However, some general issues are considered below.

In the case of a decentralized decision, through the basin committees, the discussion on the level of billing x abatement goals is a crucial interaction item of the basin committees/agencies. In fact, the explanations on the several alternatives of abatement, the respective levels of incentive billings, the financial repercussions on the agents, the environmental repercussions on the levels of quality of the bodies of water and on its more or less speedy approach to the goals established in the framework, the possible inter-sectorial subsidies, etc., are all duties of the agency in order to support the discussion and the decision being made by the committee, who, despite being true "parliaments of water", cannot make decisions without the technical input supplied by the respective agency; in the case of a centralized administration, directly by an environmental authority, all the above items should also be looked upon, but by a smaller group of decision makers.

Curves, such as the one on Fig. 3.3, have a first characteristic, a relevant technological fact which is: the accentuated exponential nature, especially in the levels of abatement which are close to 100 %, in other words, the exponential growing costs of abatement of pollution as the levels of abatement increase. This fact helps to explain a very important consequence in terms of public policies dealing with pollution combat. In general, a community will be able to engage in a depollution program, at relatively low costs during the first 10–15 years, and thus use the incentive tariff. Nonetheless, as we approach the high levels of abatement, required by the increasing scarcity of the environment and by the quality goals established in the original framework, the tariffs will also have to, in order to continue to be an incentive, be exponentially readjusted: the inescapable reality of marginal cost curves like these is that, based on currently known technology, the relative price of recovered environment increases disproportionately. In order to deal with this phenomenon, there are two complementary paths: in the first place, to increasingly use pure tariffs for financing of the interventions, maintaining values that can be assimilated by the polluter agents, though obviously delaying the process of meeting the goals set in the Framework[10]; secondly, to stimulate technological innovation, making the marginal cost curve "turn" clockwise.

In any concrete case of water resource management, evidently, there is never one unique problem being "attacked". Therefore, almost always we have to face a fight in several fronts: BOD_5, suspended solids, toxic load, nitrogen, etc. Then, in this case, we need to build curves similar to those in Fig. 3.3, for each pollutant. However, two things can occur here: on one side, the abatement technologies and their respective costs are independent among all pollutants; in this case, curves similar to that of Fig. 3.3 need to be construed for each pollutant (where one can even have a reordering of the "levels" of the several sectors); on the other side, the abatement technologies, with their associated costs, can be combined for two or more pollutants (for example, the technology that abates BOD_5 also abates suspended solids). In this case, one needs to make a proportional allocation of the total cost between the two or more interrelated pollutants, so as not to fall into double counting of the cost and unnecessarily inflating the tariffs.[11]

The informational requirements of this entire system are very amicable. The committee/agency or the environmental authority basically needs three sets of data: estimate (followed by registration) of pollutant sources and respective levels of discharge, operational and investment costs of the alternative abatements commercially available and models of dispersion/assimilation of pollutants in the receptor environment. Several studies in Brazil can already count on the above mentioned sets of data for the majority of our watercourses.

[10] Evidently, it is possible to initiate the pollution abatement process using, as of not, pure financing tariffs. This implies in specific agreements with the productive sectors that will receive the funds raised and perform the treatment for one application in the same hydrographic basin of Rio dos Sinos (see Pereira et al. 1999).

[11] The case of the Rio dos Sinos basin is enlarged in order to contemplate this possibility in Cánepa and Pereira (2001).

The Brazilian Experience in the Management of Inland Waters

Even though the Brazilian legislation has, as we have seen, all the ingredients to accommodate a water resource management within a cost-effective framework, the experience up until now, 15 years after the enactment of the main state laws and 10 years after the federal law on waters, leaves much to be desired, mainly because the process of deployment and implementation is extremely slow and timid:

1. Only one pollutant is considered in the PPP (BOD).
2. The tariffs have no incentive characteristics, they are only financing tariffs, of sharing the agreed intervention costs.
3. Moreover, tariffs, even those for financing, could fall into the category of cost-effectiveness; but, that is not what happens, for interventions are established after the tariff is collected, through "candidate" projects which have no relation whatsoever to the leveled curve of Fig. 3.3.
4. The environmental agencies, still guided by the "old" policy of Mandate—and—control, have not absorbed the radical novelty of the new legislation. There are plenty of lawyers in the area of Environmental Law who ensure that the new legislation is complementary to the former one. Now, if the old policy of Mandate—and—Control, with its emission standards for all sectors is maintained, there is absolutely no need for the charging for the use of water resources (in the best case scenario, only the abstraction of water would be charge for).

The delay in implementing a cost-effective management system of environmental resources such as air and water—being very late in comparison to what has already been achieved by advanced countries—leaves our country in a very serious moment. As was seen in the beginning of this article, the current situation in the world is one of emergency, of true global problems, which also need to be faced. Now, to do this while we have not even managed to even fully consider the issue of local/regional natural asset is a tremendous handicap.

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