The Role of Tradable Permits in Water Pollution Control

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SUMMARY

This paper was prepared as a conceptual framework to stimulate discussions on the role and applicability of tradable permits in water pollution control among participants of the Technical Seminar on the Feasibility of the Application of Tradable Water Permits for Water Management in Chile (13-14 November 2003 in Santiago de Chile). In Chile, water pollution is a major problem. Until recently, existing regulations to control water pollution consisted mainly of non-market based instruments. Innovative instruments are now being explored via a recent national law for tradable emission/discharge permits.

The instrument of tradable discharge permits is one of several market-based instruments used in water management and pollution control. Tradable discharge permits are actually among the most challenging market-based instruments in terms of both their design and implementation. Experience to date with tradable discharge permits for water pollution control has been limited and mainly comes from several regions of the US and Australia.

The paper at first introduces tradable permits as part of an overall taxonomy of economic instruments in the field of water management. In this context, three fundamentally different fields of application of tradable permits systems relating to water are presented: tradable water abstraction rights, tradable rights to water-based resources and tradable water pollution rights. The remaining of the paper deals exclusively with the latter category, i.e. tradable water pollution rights, their role and applicability in water pollution control.

The authors provide literature-based empirical evidence of the international experience with tradable water pollution rights (case studies from the US and Australia). The practical examples are presented according to different individual substances or parameters that have been the subject of trading systems (salinity, organic pollution and nutrient pollution). Lessons are drawn from the selected examples considering also the institutional and existing regulatory context of the countries in question.

Subsequently, the authors make recommendations on the strategies for introducing tradable water pollution rights, they point out opportunities and limitations and discuss the instrument's compatibility in instrument 'mixes'. The paper focuses on the specificity of water pollution trading discussing outstanding issues that should be considered for the introduction of tradable water pollution rights. For a systematic analysis of the various approaches and challenges relating to the overall design and implementation of tradable permits for natural resources at the national level, the reader should refer to the study of the OECD (2001).

It is pointed out that experience with tradable permits for water pollution control has been accumulating primarily in advanced economies with long regulatory history in water management and pollution control (the US and Australia). The introduction of trade for water pollution control has benefited in these cases from solid scientific understanding of the pollution problems in question, existing monitoring infrastructure and enforcement capacities. It is important to bear in mind that the

pre-existing (institutional and regulatory) context may be different in other countries or regions where trading schemes are being considered.

BACKGROUND AND RATIONALE

Background and Purpose

This paper on the role of tradable permits in water pollution control was prepared for the Technical Seminar on the Feasibility of the Application of Tradable Water Permits for Water Management in Chile, organized by the Inter-American Development Bank (IADB) and the National Environment Commission of Chile (CONAMA), on 13-14 November 2003 in Santiago de Chile. The objective of the Technical Seminar was to analyze and discuss international experiences on the implementation of tradable discharge permit schemes (a market-based instrument for pollution control) and evaluate the feasibility of their application in Chile.

Overall, early attempts to control water pollution followed a regulatory command-and-control approach. In many cases, the regulatory approach has led to the reduction of water pollution. Recently, there is a growing move from command-and-control to various market-based instruments in order to achieve further water pollution control. This is partly due to the fact that the cheapest and easiest-to-achieve point source reductions have occurred via regulatory command-and-control instruments, leading now to an escalation of costs to meet tougher water quality standards. Moreover, non-point source pollution, which is becoming a significant water pollution source, is not easily controlled by regulation.

The instrument of tradable discharge permits is one of several market-based instruments used in water management and pollution control; tradable discharge permits are actually among the most challenging ones in terms of both their design and implementation. Experience to date with tradable discharge permits for water pollution control has been limited and mainly comes from countries with an advanced economy such as the US and Australia.

In Chile water pollution is a major problem. Until recently, existing regulations consisted mainly of non-market based instruments. There are ambient water quality standards, standards for the discharge of liquid waste into sewer systems and watercourses. Several bans on the discharge of polluted waters into rivers and other waters used as source for irrigation or drinking water have also been in place but their enforcement has been weak (Huber et al., 1998). Innovative instruments are now being explored via a recent national law for tradable emission permits in Chile.

Scope of Paper

In this context, this paper was prepared as a conceptual framework to stimulate discussions among participants of the Technical Seminar on the role and applicability of tradable permits in water pollution control. Based on literature, it provides an overview of recent developments on the wider international application of tradable permits in water pollution (US, Australia). It builds to a great extent on the findings of Kraemer and Banholzer (1999) and Kraemer et al. (2002) on the use of tradable permits in water management and pollution control providing some updates of the trading programmes reviewed in this previous work. The description and discussion of each programme of tradable permits attempts to cover in brief information on the institutional set up of the programme, its establishment, as well as on the nature of permits, programme participants, allocation method and monitoring of the trading rules. Comments on the advantages and potential drawbacks of each scheme are also included where appropriate.

Apart from reviewing the relevant international experience, the paper makes recommendations on the strategies for introducing tradable water discharge permits and discusses their compatibility with other regulatory instruments. The paper does not attempt an extensive discussion on the design and implementation of a tradable permit system for natural resources within a country. For information on the overall design and implementation of tradable permits for environmental management, the reader should refer to the study of the OECD (2001). We focus on the specificity of water pollution trading discussing outstanding issues that should be considered for the introduction of tradable water pollution rights.

Therefore, the main objectives of this paper are to:

- Give an introduction to the role of tradable permits in the field of water management, as part of an overall taxonomy of other relevant economic instruments;
- provide empirical evidence of international experience with tradable permits for water pollution control (US, Australia);
- provide a conceptual framework for the application of tradable permits for water pollution control.

Structure of Paper

The paper is structured as follows: Section 1 and 2 have given a summary of the report and have set the background and scope respectively. Section 3 discusses the role of tradable permits in water management and pollution control, in the context of an overall taxonomy of relevant economic instruments. Section 4 presents a number of case studies from the international arena on tradable permits for water pollution control. Section 5 then discusses the application of tradable water pollution rights elaborating on opportunities and limitations, strategies for their introduction as well as their compatibility in instrument mixes. Section 6 finally concludes with remarks on the use of tradable permits in water pollution control so far and their potential for further application.

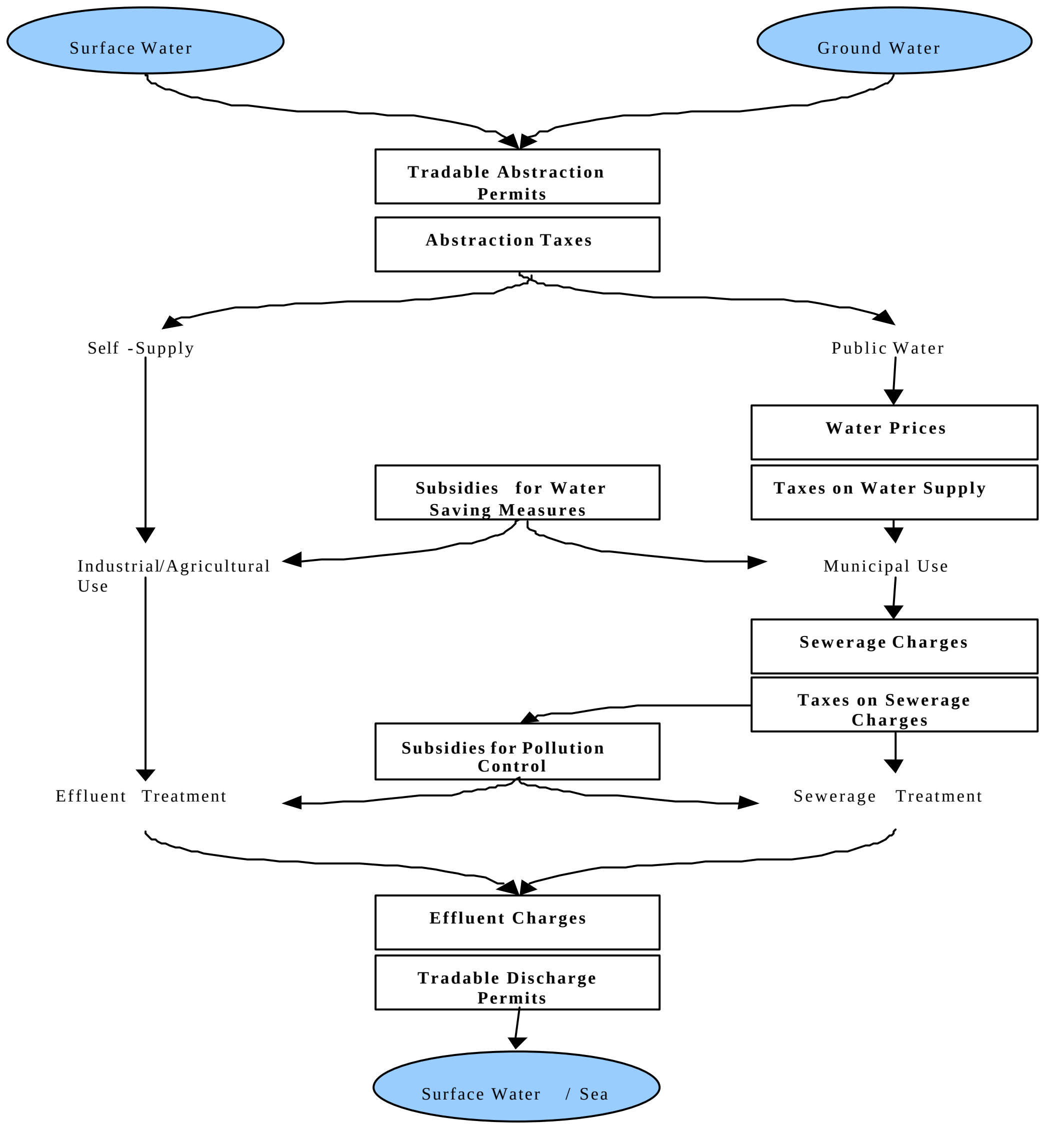
Economic Instruments in Water Management: What Role for Tradable Rights?

This section provides a taxonomy of economic instruments in water management, introduces the available instruments and defines their areas of applicability. The taxonomy is followed by a more detailed sub-section on the economic instrument of tradable permits for water management, as background to the relevant international experience presented in the next section of the paper.

Taxonomy of Economic Instruments for Water Management

The taxonomy presented in this sub-section is mainly based on the work of Kraemer et al. (2003). Figure 0 positions the respective economic instruments along the water cycle. The different aspects of the figure are expla ined in the following subsections.

Figure 0: Economic Instruments for Water Management (adapted from Kraemer, 1995a)



Abstraction Taxes

A water abstraction tax is a certain amount of money charged for the direct abstraction of water from ground or surface water (Roth, 2001). In some cases only ground water abstractions are charged to reduce the price differential between surface and groundwater abstraction, while in others, both ground and surface water abstractions are taxed, however often at different rates.

Besides their revenue-generating function, water abstraction taxes can act as incentive measures. Effective water abstraction taxes can induce a change in user behavior resulting in lower water demand and a reduction of water leakage. If the tax is set to reflect marginal – (environmental or resource) - costs of water abstraction, it enhances the cost effectiveness of the service provided. In general, water abstraction policies should consider both surface and groundwater in order to limit negative effects that more efficient pricing for one source of water will have on the other (European Commission, 2000a).

In many countries, revenues generated by abstraction charges are earmarked for explicit water management purposes, so that the proceeds from the tax are indirectly returned to those liable to pay. Water abstraction taxes may be set to reflect the relative scarcity of water and may vary by regions.

Water Prices

The instrument of water pricing has the primary goal of financing water supply infrastructure. According to the European Commission (2000b), water prices should be set at a level that ensures the recovery of costs for each sector (agriculture, households and industry) and to allocate costs to those sectors (avoidance of cross-subsidies). Water prices should in principle relate to three types of cost – direct economic costs, social costs, and environmental (and resource) costs. The estimation of each type of costs involves a different set of problems (Kraemer and Buck, 1997):

- *Direct economic costs*: Full recovery of the economic costs of water services will require that water prices include (1) the costs of operation and maintenance of water infrastructure, (2) the capital costs for the construction of this water infrastructure, and (3) the reserves for future investment in water infrastructure.
- *Social costs*: With respect to water services, the direct or indirect social benefits (for instance in the field of public health) vary largely with respect to the specific contextual settings. Calculating these costs and comparing them across cases is, therefore, not a feasible task, which prohibits their incorporation into a comparative study.
- *Environmental costs*: The environmental costs of a certain economic activity are generally not reflected in the prices established at the market-place, but appear as so-called externalities. Conceptually, the non-inclusion of negative environmental costs in price mechanisms can be discussed under the heading of subsidies. In practice though, there are great difficulties linked to the establishment of benchmarks for costs caused by environmental degradation, and to the inclusion of these costs into market-based mechanisms. Still, the principle of full cost recovery requires taking these costs into account. Given the methodological problems involved in calculating environmental externalities, the inclusion of an environmental component into water prices will be backed by political rather than economic arguments.

In addition to their financing function, water pricing policies often fulfil an incentive objective as well. Water prices which represent full costs (economic and environmental costs) provide price signals to users resulting in a more efficient water use and generate the means for ensuring a sustainable water infrastructure (Huijm, n.y.)

Sewerage Charges (Indirect Emissions)

Sewerage charges are tariffs paid for the discharge of used water. A sewerage charge is the amount of money paid for indirect discharges, that is domestic sewage or effluents discharged into the sewer system (Hansen et al., 2001). Foremost, sewerage charges have the objective of providing environmental authorities with financial resources for water management activities (financial function). Furthermore, these charges may fulfil an incentive function and are in accordance with the polluter-pays principle by internalizing treatment costs into the decision process of users through adequate price signals (Kraemer and Piotrowski, 1995).

Effluent Charges

Dischargers pay effluent charges for the direct discharge of effluents into natural waters. Usually, the charge is paid to a public or para-statal authority (Hansen et al., 2001). Payment is based on the measurements or estimates of the quantity and quality of a pollutant discharged to a natural water body (not a sewer). Pollution charges are an important step towards the realization of the polluter-pays principle even if their calculation is not based on estimates of damage costs. By levying a charge on pollution, a clear signal is given that society is no longer willing to bear the costs of pollution and that at least part of the costs of the damage caused has to be recovered directly from polluters (Roth, 2001). Pollution charges may set incentives in terms of pollution abatement promotion. In cases where the revenue generated by the charge is earmarked for measures to improve water quality, a pollution charge additionally fulfils a financial function for the improvement of water quality.

Designing optimal pollution charges that minimize the total cost of pollution (damage costs plus control costs) is a difficult task, as it requires the existence of a reasonable database and information on pollution damages. The exact calculation of charges requires information about the exact quantity and quality of the discharged waste water (Kraemer, 1995b).

Subsidies

Subsidies in general include “any measure that keeps prices for consumers below market levels, or for producers above market levels”. However, given the wide range of possible support measures, a clear-cut definition of subsidies is difficult to establish. The OECD (1996) defines environmentally adverse subsidies as “government interventions through direct and indirect payments, price regulations and protective measures to support actions that favor environmentally-unfriendly choices over environmentally-friendly ones”. This definition includes direct subsidies in the form of direct payments by the government to certain users, and indirect subsidies. Even in the absence of “explicit monetary transfers” one can speak of (indirect) water subsidies if the system of water prices in place does not adequately reflect all costs involved in producing that service. Thus the effective implementation of the principle of “full cost recovery” in the formation of water prices in turn would eliminate water subsidies (Kraemer and Buck, 1997). This conceptual perspective highlights the close relationship between water subsidies and water pricing practices. Further indirect subsidy schemes include tax concessions or allowances, guaranteed minimum prices, preferential procurement policies and cross-subsidization.

Generally, subsidies can have two main objectives: either they are instituted to compensate users for a cost they incur in response to a required action or a prohibition, or subsidies are constructed so as to set the necessary incentives for achieving a certain desired, but not required, action.

Subsidies can be of a fiscal nature and paid out of public funds or can take the form of para-fiscal cross-subsidies through redistribution between urban areas. From an environmental perspective, a subsidy consists of the value of uncompensated environmental damage arising from any flow of goods or services (Barg, 1996). As environmental damage is usually not included in water prices, subsidies *de facto* often exist.

Subsidies are a type of economic instrument that may lead to inefficient situations (OECD, 1996). However, they can create the necessary incentives for stimulating a change in user behavior towards environmentally friendly conduct or induce investment in environmentally friendly production techniques, thereby mitigating or eliminating negative effects. In some cases, like flood alleviation for example, subsidies may provide a relatively cheap option for governments, especially considering the reduction in losses that may be achieved through adequate flood proofing (Otter and van der Veen, 1999). There is, however, a danger that over the longer term, resources may be channeled to problems that are no longer high priority.

When the government grants payments in return for an environmental benefit, subsidies are a form of internalization of external benefits.

Liability for Damage to Water

With the strengthening of regulatory instruments for environmental damage reduction by individuals and firms and the growing number of emitters to which these apply, problems of control by environmental inspections become obvious. Therefore, governments are aware of the need for alternative instruments, one of which is liability for environmental damage (Bongaerts & Kraemer, 1989), including damage to water.

Environmental liability systems intend to internalize and recover the costs of environmental damage through legal action and to make polluters pay for the damage their pollution causes. To that extent environmental liability laws are a fundamental expression of the polluter-pays principle. The intention of environmental liability laws can be twofold: first of all they aim at inducing polluters to make more careful decisions about the release of pollution according to the precautionary principle and second at ensuring the compensation of victims of pollution. While liability systems assess and recover damages ex post, they can nevertheless provide incentives to prevent pollution, as long as the expected damage payments exceed the benefits from non-compliance.

For liability to be effective, there needs to be one or more identifiable actors (polluters); the damage needs to be concrete and quantifiable; and a causal link needs to be established between the damage and the identified polluter (European Commission, 2000c). Thus, liability is not a suitable instrument for dealing with pollution of a widespread, diffuse character where it is impossible to link the negative environmental effects with the activities of certain individual actors.

The instrument of environmental liability conveys several advantages[1]:

- Liability rules control pollution through the decentralized decisions of polluters to act in their own interest. Polluters will control pollution up to the point where the marginal pollution damage equals the marginal cost of control, thereby minimizing their total costs for compensating victims and controlling pollution;
- The provision that polluters must pay for the damage they cause provides great incentives to avoid environmental damage. The higher the anticipated payment in case of a damage, the higher the incentive for taking preventive measures (precautionary principle);
- Environmental liability laws constitute a significant step towards the application of the polluter-pays-principle;
- Environmental liability will also be reflected in prices and is thus an important contribution towards realizing the principle of "ecologically honest prices".

Tradable Permits for Water Management

If disagreement exists over the allocation of water from shared resources among segments of the population, a potential instrument is the creation of tradable rights to use or pollute water and the creation of efficient markets on which the rights can be traded. The rationale behind water allocation through tradable rights is that in a perfectly competitive market, permits will flow towards their highest value use (Tietenberg, 2000). Permit holders that gain a lower benefit from using their permits (for example due to higher costs) would have an incentive to trade them to someone who would value them more. A sale will result in a situation of mutual benefit: the benefit the permit holder reaps from selling his permit will exceed the benefit he derives from using it, while the buyer gets more value out of the permit than he has to pay for it.

Several prerequisites must be fulfilled for the successful implementation of a tradable permit system. First of all, property rights must be well defined and specified in the unit of measurement (Kraemer et al., 2002). As a second point, water rights must be enforceable to secure the net benefits flowing from the use of the water rights for the rights holder. In the ideal case, transferable water rights should be separate from land use in order to create exposure to the opportunity to realize higher valued alternatives (Pigram, 1993). Finally, an efficient administrative system must be in place to ensure that the market works appropriately (Armitage et al., 1999).

Situations in which the conditions may not be adequately met include the possibility for market power, the presence of high transaction costs and insufficient monitoring and enforcement (Tietenberg, 2000). However, even in the presence of these imperfections, tradable permit programs can be designed to mitigate their adverse consequences.

[1] Source: http://www.eeb.org.

When discussing tradable permits systems relating to water, three fundamentally different fields of application can be discussed which are presented below.

Tradable water abstraction rights

Tradable water abstraction rights are used for quantitative water resource management. These water rights can be permanent and unlimited (property rights to the water resource) or temporary and limited (transferable rights to use water without right of abuse). In relation to tradable water rights, distinctions can be made regarding the "intensity" of trading, which can be permanent or temporary (seasonal) or even one-off. One of the main objectives when introducing tradable permits to use water is often to provide an instrument for the re-allocation of water rights so they can be put to more (economically) beneficial use. (Kraemer and Banholzer, 1999).

Even though the approach of tradable permits appears to be conceptually sound and should be attractive for efficiency reasons, only the Commonwealth of Australia, the US, and Chile have accumulated much experience with tradable water abstraction permits. Some experience also exists in Spain and Mexico. Australia and the US are both federations where examples of tradable water permits are found in more than one state. There have been different patterns of diffusion in the use of tradable permits in both cases, and the experience is not at all the same. Nevertheless, the hypothesis can be established that federal structures facilitate innovation in the use of policy instruments because they provide freedom for regional (state) authorities to experiment, and to create a framework which facilitates "policy learning" on the basis of these experiments (Kraemer and Banholzer, 1999). In Chile, there are water markets, largely linked to the agricultural sector, since the Chilean government enacted the 1981 Water Code. The latter privatized water rights, promoted free market forces, and sharply reduced government regulatory powers in water management (Bauer, 2003). In Mexico, bulk trades of water for irrigation purposes between Water User Associations started after the 1992 Mexican National Water Law came into practice (Kloezen, 1998). Finally, in Spain, local historically grown water markets have existed for a long time (e.g. in Valencia, mostly for groundwater) (Garrido, 1998). A new water law came into force in 1999 aiming to incorporate market systems in water management.

So far, the most "lively" trading appears to take place within the agricultural sector, with transfers from agriculture to other sectors (hydropower or municipal use) being relatively rare. Nevertheless, such inter-sectoral transfers are perhaps the most significant in economic terms as they can be expected to provide important added value.

Reviewing recent developments in existing and new water trading schemes, Kraemer et al. (2002) noted a growing concern about the environmental consequences of water trading, primarily in Australia and the United States. Concerns mainly relate to inadequate in stream flows (leading to endangerment of wildlife habitats, certain fish species etc.).

Tradable permits to water-based resources

Tradable permits can be applied to the use or consumption of water-borne resources, such as fish or the potential energy of water at height or the kinetic energy of water flowing. There are several interesting case studies on this field of application of tradable permits. The case of the Scottish salmon fisheries (see Box) shows that trading may work, as long as there are no significant externalities (i.e. impacts on, or from, other water uses or functions). However, the conflict between fishing as a recreational activity (rather than to secure the nutritional base of the anglers) and conservation requirements is also highlighted (Kraemer and Banholzer, 1999).

Freshwater Fisheries: Fishing Rights in Scotland

In Scotland, responsibility for protecting and developing inland salmon fisheries rests with District Salmon Fishery Boards. Unlike in England and Wales, individual rod licenses (fishing licenses) are not issued. Instead, salmon fisheries are privately-owned and operated by the owner or tenant, within a legislative framework set by central Government. Although salmon does not "belong" to anyone, there is no public right to fish for salmon. The right to fish belongs to the person who owns the exclusive rights at any one site (fisheries). In most of Scotland, such rights are owned independently of the land itself (Scottish Office, 1997).[2]

The Crown Estate still owns many fisheries and leases them to fishermen on standard five-year leases. Elsewhere, rights may be held by individuals, public companies, businesses, or fishing clubs. Fishery owners in any District may set up a District Salmon Fishery Board. The owners can rent their fishing rights to others, and where they do so, it is usually on a daily or weekly basis. Time-sharing has also become increasingly popular in the last 10 years, so that individuals can get a lease to fish for specific period of the year.

The majority of salmon anglers pay to rent a fishery for a specific period of time. The rental price depends on the prospects of catching fish, and is often based on the five-year average catch. On the major Scottish salmon rivers (i.e. where the great majority of fish are caught), prices for purchasing beats currently range from £6 000-8 000 per fish, based on the average catch per year for that beat. The fact that individuals own the exclusive right to fish at a site (e.g. river or loch) is now considered to be one of the main obstacles to the designation of freshwater habitat protection areas in Scotland.

Source: Kraemer and Banholzer, 1999

Tradable water pollution rights

Tradable discharge permits, or tradable water pollution rights, are used for the protection and management of (surface) water quality. Such pollution rights can relate to point or to non-point sources, and trades can even be arranged among different kinds of sources. Under this approach, a responsible authority sets maximum limits on the total allowable emissions of a pollutant. It then allocates this total amount among the sources of the pollutant by issuing permits that authorize industrial plants or other sources to emit a stipulated amount of pollutant over a specified period of time. After their initial distribution, permits can be bought and sold. The trades can be external (between different enterprises) or internal (between different plants within the same organizations) (WHO/UNEP, 1997).

In contrast to trading water abstraction rights, which can be expressed rather simply in volumetric terms, trading in permits to pollute water has to cope with a much higher degree of complexity. Water can be polluted by a number of substances (or classes of substances), which have very distinct effects

2 Information on Scottish salmon fishing was provided by Clare Coffey, Institute for European Environmental Policy, London.

on water-based ecosystems. The presence of two or more pollutants at the same time can lead to synergies, both positive and negative. Furthermore, most sources of pollution contribute more than one substance that is dangerous to the water environment. In relation to water pollution much more than with water abstraction, it is the precise location of a discharge that determines the environmental consequences (Kraemer and Banholzer, 1999).

European Union: Urban Waste Water Treatment Directive

The European Union can adopt Directives that are legally binding on its Member States. Among its legislation concerning water resource protection and management, the Urban Waste Water Treatment Directive (91/271/EEC) has a reputation for being the most expensive item of European legislation in the environmental field. Its purpose is to stimulate Member States to invest in the collection and treatment of urban wastewater. Different requirements and deadlines apply to “sensitive”, “normal”, and “non-sensitive” areas, meaning water bodies and their catchment areas. The Directive leaves the Member States much freedom in its implementation, such as a choice between limit values for treatment plant effluent and percentage reduction goals or a choice between reducing phosphorus (P) or nitrogen (N).

In sensitive areas (i.e. areas tending towards eutrophication, because of excessive levels of P and N), adequate collection and “more stringent than secondary” (i.e. tertiary) treatment systems were to be installed by 31 December 1998 for all discharges from agglomerations of more than 10 000 population equivalents. Discharges from such systems must meet emission limit values for either P or N. The limit values for P are 2 mg/l in agglomerations of between 10 000 and 100 000 population equivalents and 1 mg/l in larger agglomerations (measured as P). The limit values for N are 15 mg/l for agglomerations of between 10 000 and 100 000 population equivalents and 10 mg/l in larger agglomerations (measured as N). Alternatively to the use of limit values, P may be reduced by 80 per cent or N by 70-80 per cent.

The Directive makes provisions for trades in P and N emissions. Article 5(4) of the Directive states that the above requirements need not apply in sensitive areas, where it can be shown that the minimum percentage of reduction of the overall load entering all urban waste water treatments plants in that area is at least 75 per cent for total P, and at least 75 per cent for total N. With the wording “overall load entering all urban waste water treatments plants”, this Article clearly opens the possibility for emissions trading within an “emissions bubble” thus described. However, it also establishes restrictions. Notably: (i) the “bubble area” must be a “sensitive area” within the definitions of the Directive; (ii) the reduction would need be attained over all urban waste water treatment plants and not only the larger installations; and (iii) the reduction probably must be attained for both P and N simultaneously. The weight of these restrictions is not clear, but is unlikely to present serious obstacles to any pragmatic implementation of an emissions trading regime.

None of the EC Member States so far appear to have taken advantage of the possibility of establishing emissions trading in “sensitive area” bubbles, and the possibility appears to not even have been discussed among the national experts in the Technical Committee established under the Directive. As an indication of some interest, the Netherlands have mentioned the possibility in their first implementation report to the European Commission, and have asked a national committee to develop scenarios. The evident lack of general interest so far may be regrettable, since a potentially important source of economies in pollution abatement costs remains untapped, in spite of the wide-spread concerns about the financial implications of the Directive.

Source: Kraemer and Banholzer, 1999

In general, experience to date with permits to pollute water resources is limited, but it appears that trading can be part of the answer to achieve better water quality (Faerth, 2000). Mainly US (since the 1980s) and Australia, both federations, have accumulated experience with tradable water pollution rights. The European Union (EU), which in some ways resembles a federation, provides another example. The EU does on occasion make use of bubbles[3] for instance in the implementation of the Montreal Protocol on substances that deplete the ozone layer. It has also adopted a provision allowing for water pollution trading in the context of its Urban Waste Water Treatment Directive, but this has not yet been applied anywhere (see Box) (Kraemer and Banholzer, 1999).

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3 In the concept of "bubbles", requirements of pollution abatement are applied to the sources of an industrial facility owned by the same firm, by taking all these sources as a whole (OECD, 2001). However, the bubble can also encompass polluting sources belonging to several firms. An imaginary bubble is placed over a set of sources and only the total quantity of pollutants emitted under the bubble is taken into consideration. Thus, polluters are free, within certain limits, to offset excess emissions from one source by a reduction made on another source, as long as overall quantity is not exceeded.

TRADABLE WATER POLLUTION RIGHTS: THE INTERNATIONAL EXPERIENCE

As illustrated in the previous section, tradable water pollution rights, which are the focus of this paper, are one type of market-based instrument used for water pollution control. In this section, examples of international experience with water pollution trading are reviewed on the basis of selected case studies.

Additionally to the description of tradable water pollution rights given in the previous section, water pollution rights can be further differentiated in relation to the polluting substance (or class of substances) in question. Water pollution permits can contain long lists of substances and parameters that have to be observed. It is not surprising; therefore, that there are no examples of trading systems in water pollution as such, but only in relation to individual substances or parameters (salt, organic oxygen-depleting substances, and nutrients) Accordingly, the practical examples in this section are presented according to different individual substances or parameters (salinity trading, organic pollution rights trading and nutrient pollution rights trading).

The practical examples presented come from the US and Australia which have been the main regions with extensive application of this type of economic instrument for water pollution control. The description of the cases is based on two previous reviews on water-based tradable permits by Kraemer and Banholzer (1999) as well as Kraemer et al. (2002). Where information was available, these examples have been updated with recent developments in the context of this paper.

Salinity Trading

Salt pollution in freshwater systems affects the suitability of water for many purposes, such as irrigation or drinking water supply. It can also have significant environmental effects on relatively sensitive ecosystems that rely on brackish water, such as in estuaries. The concentration of salt ions is relatively easy to assess by measuring the electrical conductivity of water. Conductivity is not a specific indicator of toxicity, nor is it a suitable proxy for dangerous substances. It is however, a useful parameter when measuring the concentration of salts, the nature and origins of which are well understood.

Salt pollution usually originates in the mining industry (salt mines, but also mine water from coal mines, for instance) or the energy sector, where cooling by water evaporation leaves saline residues. Salt pollution can also occur naturally as a result of erosion or natural dissolution of salt deposits. Where salt concentrations (rather than loads) trigger problems, dilution by fresh water can provide a (temporary) solution.

Although salt pollution rarely reaches levels where corrective action has to be taken, the examples of where it does can be instructive. Chloride pollution of the international river Rhine, for instance, provided the stimulus for developing the multilateral system of the riparian states for managing economic and environmental aspects of the river.

The most prominent examples of salinity trading come from Australia, with the inter-state trading case in the Murray-Darling Basin, and the more market-oriented approach in the Hunter River in the State of New South Wales. In both cases, the concern is for reducing and “managing” salt pollution to reduce harm.

Inter-State Salinity Trading Case: Murray-Darling Basin (Australia)

Interstate salinity trading came into force in 1992 as part of the Murray-Darling Basin Salinity and Drainage Strategy, administered by the Murray-Darling Basin Commission, on behalf of the States of New South Wales, Victoria and South Australia. The interstate salinity trading is based on a system of salt credits and debits. The salt pollution rights are not freely traded by industries or individuals, but are exchanged between the governments of the participating states. Credits are earned by investing in capital works to manage salt entering the river. Although credits are tradable between the States, they are generally applied within each State to offset debits from drainage entering the river system (James, 1997).

The Salinity and Drainage Strategy has been successful in achieving a net reduction of 57 EC (Electrical Conductivity) units in the lower river Murray. However, investigations throughout the 1990s showed that increasing salinity in the Basin is threatening the further success of the Strategy. Therefore, a new Basin Salinity Management Strategy 2001-2015 has been developed to ensure that further activities in the Murray-Darling Basin against salinity are successful. The new Strategy establishes a basin-wide target, with Queensland also participating, for river salinity at a level of less than 800 EC units for 95% of the time over 15 years at Morgan, South Australia (downstream State). The end-of-valley target is in effect a ‘cap’ on salinity pollution. The effective date for the new arrangements was 1 January 2000 (Murray Darling Basin Ministerial Council, 2000).

The system of salinity credits continues, but now operates basin-wide. Each government will contribute to joint or individual works that will reduce the salinity of the shared rivers, thus earning salinity credits. Any work within a State that further reduces salinity in the shared rivers will attract additional credits for that State. All States will incur debits based on the basis of the estimated shortfall in protecting shared rivers and for specific actions such as drainage that increase salinity in the shared rivers. The Murray Darling Basin Commission maintains a register of works undertaken and the salinity credit and debit impacts. The salinity impact of any proposed irrigation scheme must offset by acquitting credits in the register. A review of the salinity debit and credit accounting system will be undertaken after 2015 (Murray Darling Basin Ministerial Council, 2000).

Salt Pollution Trading Case: Hunter River (Australia)

The Hunter River Salinity Trading Scheme is Australia's first active emissions trading scheme, put in operation as a pilot in 1995 by the Environmental Protection Agency of New South Wales (NSW EPA), and has proved very successful (NSW EPA, 2001*a*). It was established to resolve a longstanding and frequently acrimonious dispute over the impacts of saline discharges to the Hunter River.

In the context of the scheme, each discharger is allowed to discharge a specified percentage of the total allowable salt load, which is calculated in relation to conductivity levels. The scheme was developed from the existing salt licensing regime and was initially limited to coal mines and the power generation industry of Pacific Power. Initial experience showed that conductivity levels remained within the target limits, with only a few trades occurring. Low trading levels were due to uncertainty about long-term needs, arrangements for longer-term allocations (James, 1997) and inexperience with the scheme (NSW EPA, 2001*b*). It is possible that the purely paper-based trading mechanism had inhibited the potential volume of trades. The NSW EPA then developed a 24-hour on-line credit exchange, to make trading for license holders faster and easier (NSW EPA, 2001*b*).

In general, the salinity target (900 EC unit level at Singleton monitoring point and 600 EC units at Denman) has not been exceeded as a result of participant's discharges since the scheme has been in operation. There has been some a few occasions where the target has been exceeded, primarily caused by saline diffuse run-off (NSW EPS, 2001*a*). Notably, the number of occasions in which the target has been exceeded, decreased from 33% before the introduction of the scheme to 4% currently (NSW EPA, 2001*b*). The trading scheme operates during high flows. No discharge is allowed during low flows and unlimited discharges are allowed during flood flows. The Department of Land and Water Conservation estimates the total allowable salt discharge at high flows so that the river is below the salinity target.

Trading has allowed major industries such as coal mining and power generation, to discharge saline water on a managed basis. It has also reduced significant costs of water storage or treatment that would otherwise have been incurred by those industries under the previous discharge management system, which included a traditional licensing strategy requiring industries to minimize discharges and discharge a small volume of saline water to the river at all times. A major advantage of the scheme is an extensive monitoring network, which monitors each authorized point of discharge (NSW EPA, 2001b).

In 1999 and 2000, the number of trades increased, with 31 trades occurring in 2000 (NSW EPA, 2001*b*). Due to the success of the scheme during its pilot phase, the EPA established the scheme through a new specific legislation. The *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation* 2002 permanently implements the existing pilot trading and places it into a firm legislative framework (NSW EPA, 2003). The Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002 brought in the following main elements:

- The creation (reissue) of 1000 tradable salinity credits of different life spans (2 to 10 years), which were allocated without charge to license holders.
- The expiry of 20% of the credits every 2 years, and the reallocation of those credits by public auction, with each credit then valid for 10 years. Therefore, the mechanism for allocation, holding and trading credits has been altered, moving from administrative allocation of credits to initial allocation based on current holdings (grandfathering) followed by 2-yearly credit auctions. Auctions will ensure new industries can readily enter the scheme and access credits.
- The creation of new administrative roles: the *Services Coordinator* who is responsible for river monitoring, modeling and River Register services, the *EPA* which provides licensing, regulation, online credit register and exchange, the *Hunter River Valley Salinity Trading Scheme Operations Committee* which is a stakeholder committee and deals with issues relating to the day-to-day operation of the scheme (NSW EPA, 2003).

The success of the scheme, which has been designed to suit the unique characteristics of the Hunter River catchment, is due to a number of factors. First, having a good understanding of the river on the basis of long-term data collection and modeling of the river's behavior was vital to designing an effective scheme. Secondly, the scheme was a result of extensive consultation with the community and was thoroughly tested in 7-year pilot scheme (1995-2002) before being formally established through legislation. The fact that the scheme is underpinned by legislation is also important in itself; The EPA believed significant benefits would occur from the new regulation such as increased certainty that the scheme will continue to function, which provides investors with a longer planning horizon (NSW EPA, 2001*b*). Finally, the scheme is supported by real time data and trading with continuous measurements of river flow and salinity, modeling expertise as well as the online daily River Register and Credit Trading (NSW EPA, 2003).

Trading of Organic Pollution Rights

A more challenging aspect of trading in water pollution permits is presented by organic pollution. Such pollution consists of a multitude of different substances containing carbon, any one of which may be present at concentrations below critical levels. Such substances can originate from human wastes (e.g. sewage), but also in industrial effluent (e.g. food and beverage industries), as well as from rainwater run-off. Organic pollution can be controlled (but not fully eliminated) by treatment, and the ability to release such pollution into recipient water bodies typically has a significant impact on the cost of treatment.

(Almost) all organic pollution is naturally degraded or "metabolized" by biological mechanisms in natural water systems, consuming oxygen in the process. When oxygen is consumed, the level of oxygen dissolved in the water decreases. In extreme cases, especially during periods of low flow or in warm water, the water can be deprived of oxygen to the point that fish and other life in rivers and lakes die. This is not a slow process but can often "hit" a river as a consequence of a single pollution incident, such as storm water over-flow being discharged. It is therefore vital to control overall pollution with oxygen-consuming substances, and to ensure sufficient levels of dissolved oxygen in waters.

The example presented below refers to the Fox River in the US.

Organic Point Source Trading Case: Fox River, Wisconsin (USA)

In the US, the State of Wisconsin established the legislative basis for an operational water-pollution permit market. The Wisconsin Department of Natural Resources approved the trading of rights to discharge into the Fox River as early as 1981. Point sources of water pollution can trade rights to discharge wastes that increase biological oxygen demand (BOD). The Wisconsin programme was aimed at providing flexibility for point sources, which are in this case paper mills and municipal wastewater treatment plants, in meeting State water quality standards. Sources that reduce discharges containing BOD below permitted amounts are allowed to sell the excess reductions to other sources. The pulp and paper mill effluent guidelines suggested that substantial costs would be incurred to meet the stringent limits required by the water quality standards because of the large numbers of dischargers concentrated in a few miles of the State streams. Although early studies indicated several potentially profitable trades involving large cost savings (in the order of US$ 7 million), to date only

two trades have occurred (Nishizawa, 2003). In fact, the effluent guidelines now appear to have far overstated the needed expenditures. Costs in addition to those needed to meet the national point source requirements were not incurred (Carlin, 1992; see also O'Neil, 1983; O'Neil *et al.,* 1983).
Under this system, permission to trade will only be granted if the discharger meets certain preconditions:

- the plant acquiring the rights must be new or growing, or at least unable to meet the discharge limit despite working efficiently (this seemingly prohibits trades that merely reduce treatment costs or speculative acquisitions);
- every firm has to prove the increase in water pollution is necessary;
- traded rights must have a life of at least one year, but no longer than the seller's discharge permit expiration date.
- In a 1992 EPA Report, Carlin judged the trading to have been disappointing (Carlin, 1992, page 6-29). He stated three reasons for the limited activity:
- Dischargers developed a variety of compliance alternatives not contemplated when the regulations were drafted.
- There ... remained questions about the vulnerability of the programme to legal challenge, since the *Clean Water Act* does not explicitly authorize trading (implying uncertainty about the legal viability of the rights being traded).
- The State imposed severe restrictions on the ability of sources to trade (constrained scope for trading).

The literature suggests that numerous administrative requirements have also added to the cost of trading and lowered the incentive for facilities to participate (WHO/UNEP, 1997). David (2003) mentions that along the Fox River there are only five pulp and paper mills and two municipalities on each of the three segments, which are too few for a reliable market to exist. Moreover, potential gains from trade were not substantial making trade unattractive to operators.

Trading of Nutrient Pollution Rights

The last category of water pollution trading refers to nutrients. Nutrients (i.e. nitrogen and phosphorous) are not in themselves dangerous to water or water-based ecosystems. In fact, they are necessary components of plant life. That is why they are applied as fertilizers to enhance plant growth. They also appear in domestic sewage in significant concentrations and loads. However, in water bodies, they stimulate plant (algal) growth, which consumes oxygen and can thus lead to fish kills.

In many respects, the logic of nutrients trading follows that of trading in organic pollution permits. However, since agriculture is an important source of the former, there is scope here for trades between point and non-point (or diffuse) sources. In the following paragraphs, one example is presented relating to the Hawkesbury-Nepean River in New South Wales (Australia). This example is one where "trades" (in the form of intra-firm allocations) affect point sources only. The results for the first three years of the operation of the programme were rather positive (NSW EPA, 2001c).

Further examples are presented from the US including the Tar-Pamlico Basin in North Carolina (case of point-point source trading also allowing for point-non-point trade), the case of Lake Dillon and the case of the Cherry Creek Basin in Colorado (both involving point-non-point source trading). The Chesapeake Bay nutrient-trading programme is also described as part of a number of other on going and under development effluent trading projects of the US EPA and several States.

Actually, despite the considerable effort by the US EPA and individual states to implement the concept, the trading of emissions to water has yet to live up to its full promise (NCEE, 2001). EPA, in particular, has been on the forefront of the effluent trading concept and it composed a set of guidelines for developing trading programmes in 1996 (EPA, 1996a). New efforts by the EPA to implement its so far little-known provision for Total Maximum Daily Loads (TMDLs)[4] in areas with impaired water quality are expected to vastly increase the use of effluent trading (NCEE, 2001), so as to lower compliance costs of affected sources. Parties to the water trading negotiate within the overall loading capacity determined under the TMDL. Trades can occur within TMDLs through development of final allocations among participating sources or, if a TMDL is already in place, by revisions of allocations to reflect proposed changes in individual load reduction responsibilities by trading (EPA, 1996). To encourage experimentation with trading schemes, the EPA issued a water quality trading policy in 2003 (EPA, 2003). The policy supports trading of nutrients and sediment load reductions. It is not a regulatory rule but sets objectives and guidelines for scheme design.

Hawkesbury-Nepean River (Australia)

Three sewage treatment plants of Sydney Water Corporation (SWC) in the South Creek area of the Hawkesbury-Nepean River are the participants of a ”bubble”-licensing scheme with the aim of obtaining improved environmental outcomes at lower cost. The owners of the individual sources within the bubble are permitted to adjust their discharges by trading parts of their nutrient discharge allocations, provided the aggregate limit is not exceeded. The ”bubble”-licensing scheme commenced in 1996 developed by the EPA of New South Wales and set nutrient reduction targets until 2004 for both phosphorus (83%) and nitrogen (50%) (James, 1997). It is basically a small self-contained emissions trading scheme and it functions within a strong regulatory framework.

The NSW EPA conducted a review of the Scheme’s first three years of operation (NSW EPA, 2001c). It concluded that Sydney Water Corporation has complied with the “bubble” load limits, while significant reductions in nutrient discharges have been achieved. However, it is yet early to conclude on the environmental response to the discharge reductions, based on the available monitoring data. Both discharge monitoring of the individual treatment plants as well as ambient monitoring is carried out by SWC to measure the impact of nutrients from South Creek on the main reach of the river. Additionally, new scientific information on the impact of nutrients suggests that there may be a need for a further nitrogen reduction.

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4 A Total Maximum Daily Load (TDML) should be developed by States and is the process under the Clean Water Act that establishes the maximum pollutant load a water body can receive without violating water quality standards. A TMDL describes how much pollution can be discharged into a water body and who is allowed to discharge it. It includes allocations of pollutant loads among sources: wasteload allocations for point sources, load allocations for non-point sources, background loadings from natural sources, and margins of safety to ensure achievement of water quality goals (EPA, 1996). States establish TMDLs for every location that will not meet water quality standards given the current regulatory framework.

The possibility of including non-point sources in the “bubble” is increasingly discussed and should be further explored (NSW EPA, 2001*c*). The “bubble” - licensing scheme could provide a strong basis for extending trading to incorporate diffuse sources, if further work could provide a basis to quantify the differing impacts of point versus non-point discharges. Point and non-point sources are not considered currently directly comparable, due to the dependence of non-point discharges on weather events. However, including non-point sources in the “bubble” could be particularly worthwhile if the costs of reducing diffuse discharges were significantly lower than for point sources, after taking into account appropriate trading ratios to reflect their lesser impact. Additionally, any effort to extend the bubble scheme to diffuse sources must recognize the complex array of other initiatives, which aim to address water quality problems from diffuse sources. Such initiatives are storm water management and several integrated catchment management processes (NSW EPA, 2001c).

Overall, the “bubble”–licensing scheme is considered successful, since it allows flexibility in capital infrastructure planning by allowing investment in one or two plants opposed to all three, as would occur under uniform concentration limits. Long–term cost savings are estimated to be A$45.6 million (or 37%) compared to requiring plants to meet uniform reduction individually (NSW EPA, 2001c).

Tar-Pamlico River, North Carolina (USA)

The Tar Pamlico Basin was designated "nutrient sensitive water" and was given a basin-wide "bubble" (annual, collective nutrient loading cap for 14 point source dischargers of the Tar-Pamlico Basin Association) for nutrient pollution in 1989 (Anderson and Snyder, 1997). The Tar-Pamlico Basin Association administers the scheme and facilitates trade of “shares” to the “bubble” emission limit among member pollution dischargers (Association members), and with non-member farmers who reduce field run-off and collectively reduce the discharge of phosphorous and nitrogen to the Pamlico estuary. Point sources accounted for only 15 per cent of the total nutrient load in the watershed, with the majority coming from agricultural and other non-point sources. Any member of the Association can reduce nutrients internally, trade within the group, or pay fees to a fund that goes toward non-point source reductions (non-point source (NPS) fund). The funds generated from effluent charges are then used to reduce nutrient loads from non-point sources. Farmers in the region are paid to adopt management practices that reduce nutrient runoff. The transactions among these point and non-point source polluters represent a distinguishing feature of the Association’s procedures (Riggs and Yandle, 1997).

Under Phase I (1991-1994), municipal sources were allowed to offset excess discharges with nutrient reduction credits obtained through contributions to the NPS fund. Phase I nutrient reductions were greater than the desired goal, due to the low-cost improvements at the municipal wastewater treatment facilities. It is worth noting that the estimated cost would be US$7 million to achieve the same level of wastewater treatment plant nutrient reductions that can be achieved with US$1 million by investing in non-point source pollution control (Great Lakes Trading Network, 2001).

Phase II of the programme runs until December 2004, and foresees a 30% reduction for nutrients. A main component of Phase II is wetland restoration and identification of areas of major non-point pollution in order to set action priorities. Two signatories to Phase I of the programme, the Environmental Defense Fund and the Pamlico-Tar River Foundation, did not endorse Phase II, because they were concerned about the programme's ability to address non-point pollution sources and the nutrient cap for point sources (EPA, 1996b).

Under the Tar Pamlico Basin Nutrient Trading Programme, point source/point source trading has occurred under Phase I and continues under Phase II, allowing point sources to optimize the cost of achieving the nutrient cap established for the Association. To date, point/non-point source trading has also occurred in excess of US$750,000 (Great Lakes Trading Network, 2001).

Although an in-depth evaluation of the Tar-Pamlico trading scheme is so far missing in the literature, it is certainly one of the most frequently heard about programmes in the US and is considered in overall a quite successful one. Nevertheless, discussions on Phase II have indicated potential problems of trading to deal with non-point pollution sources. It may be worth evaluating more into depth the success of the specific instrument of tradable permits, by comparing the results of trading with the potential results (and costs) of alternative pollution reduction instruments in the Tar Pamlico Basin (Kraemer et al., 2002). According to Nishizawa (2003), the Tar-Pamlico case has also shown that if a trading programme effectively incorporates existing institutions, such as soil conservation districts and agricultural cost-sharing programmes, transaction and administrative costs can be significantly lowered.

Lake Dillon, Colorado (USA)

Lake Dillon of Summit County in Colorado, a tourist attraction and a significant source of water supply for Denver, has been under significant pressure from phosphorus discharges. Four municipal treatment plants, sixteen small treatment plants, one industrial plant and numerous non-point sources discharge waste into the reservoir. Runoff from towns and ski areas is the main non-point source of phosphorus, along with selected inadequately managed septic systems (EPA, 1996*b*). This situation caused a coalition of concerned stakeholders to form the Phosphorus Club. The Phosphorus Club came up with an innovative strategy called the Dillon "bubble" also establishing the first trading programme in the US (Apogee Research, Inc., 1992). After annual discharge rights of phosphorus load were allocated for every point discharger, trade between point and non-point sources of phosphorus around Lake Dillon has been allowed since 1984. Due to the uncertainty related to the control of non-point sources credits for non-point pollutant reductions were only traded for point loads at a 2:1 ratio. This means that a point source had to reduce two tons from non-point sources (that existed before 1984) before it could increase its own discharge by one ton. Economically, such a trade can still be interesting for the discharger: the marginal cost for removal of one pound of phosphorus from a wastewater treatment plant is estimated US$860, while the average cost of non-point source control is US$119 (Carlin, 1992). Thereby, municipal facilities are allowed to obtain phosphorous reduction credits by funding controls to reduce phosphorous loadings from existing urban non-point sources.

Until 1988, the basin management authority approved no trading, since critical loads were not exceeded (Carlin, 1992). Until the end of 1996, a few trades had taken place between point and non-point sources. The Lake Dillon phosphorus-trading programme has refocused at maintaining equitable non-point-non-point source trading and enforcement. New non-point sources must offset all of their discharges by using a trading ratio of 1:1 with existing non-point sources. The co-operative management approach that grew out of developing the option of the trading programme is considered by a number of stakeholders as the reason why Lake Dillon has succeeded in maintaining high water quality. When point-non-point source trading occurs, point source discharge permits include information on the record of the credit amount, specified construction requirements for non-point source control as well as monitoring, reporting requirements, and operation of non-point source best management practices (BMP) (EPA, 1996*b*). The lake Dillon trading programme is coordinated by the Summit County Water Quality Committee, which distributes phosphorus credits, identifies potential BMP projects, ensures monitoring is performed and non-point source pollution reduction programmes, such as covering of septic tanks, are implemented.

Trading has still been very slow due to limited population growth and a recession in the region. Moreover, the wastewater treatment plants have found cheaper means of controlling phosphorus than were previously envisioned. In the future, however, opportunities for further control at the treatment plants are thought to be limited, and population growth seems to be evident, leading to the conclusion that more trading activity is likely (NCEE, 2001).

Cherry Creek, Colorado (USA)

The Cherry Creek reservoir near Denver is an important recreation area and water supply source. A total phosphorus standard was developed in 1984 for the reservoir, as well as a Total Maximum Daily Load (TMDL) (EPA, 1996*b*) to prevent eutrophication and maintain water quality standards established by the Colorado Water Quality Commission. The Cherry Creek Trading programme allows certain point source polluters to earn phosphorus reduction credits through the control of non-point source phosphorus discharges (Carlin, 1992). The TMDL requires urban non-point sources to reduce phosphorus loads by implementing best management practices. However, non-point sources, which account for approximately 80% of the basin's phosphorus load, have to reduce their loading by 50% on their own, and only reductions beyond these required non-point reductions can qualify for trading (Great Lakes Trading Network, 2001).

Initially, the Authority has the possibility to engage in two types of trade: trades of phosphorus reduction credits generated through authority water quality improvement projects and trades of credits generated through private projects. More specifically, the Authority has four completed non-point source water quality improvement projects that generate phosphorus reduction credits under the trading programme. Credits from Authority projects are placed in a Trade Pool for transfer to individual dischargers. The Authority also reviews similar privately constructed projects and assigns credits to the private party accordingly. All credits are quantified through direct water quality monitoring. Dischargers may purchase credits from the Trade Pool, if they fulfill certain requirements. They should namely demonstrate the requisite need for the increased phosphorus allocation, their wastewater treatment facility should operate and continue to operate so as to achieve expected phosphorus levels, and they should comply with the existent effluent limits. The Authority itself transfers credits to dischargers from the trade pool on a long-term basis, but does not convey ownership of credits in such transfers (EPA, 1996b).

Development and credit use are required to be consistent with a basin plan established by the Cherry Creek Basin Water Quality Authority. The Cherry Creek trading programme is being revised to reflect baseline allocations under an updated TMDL (Great Lakes Trading Network, 2001). To date, there has been no need to trade at Cherry Creek since phosphorus effluent still remains below the allowed limits. When regional economic growth compels wastewater treatment facilities to achieve greater phosphorus reductions, the credits will be available (NCEE, 2001).

Chesapeake Bay (USA)

The Chesapeake Bay is the largest estuary complex in North America. In the early 1980's, research carried out by the US EPA revealed that low dissolved oxygen in the Chesapeake Bay due to nutrient enrichment was a major problem, and the estuary was in need of a collaborative restoration effort. Therefore, the US EPA, the States of Maryland, Virginia, Pennsylvania, the District of Columbia and the Chesapeake Bay Commission signed the 1987 Chesapeake Bay Agreement. According to the Agreement, a 40% reduction of nutrients, compared to 1985 levels, in the Bay is necessary to restore its health by the year 2000 (Wiedeman, 2001). New restoration commitments were adopted under the agreement Chesapeake Bay 2000, which aims to remove the Bay and its tidal waters from the list of impaired water bodies for nutrients by 2010. This would require nutrient reductions far beyond the 1987 40% goal. In the meantime, growth in nutrient load may be expected due to increases in sewage flows and polluted runoff from new development. If these goals are not achieved by the deadline date, a TDML for the whole watershed (more stringent water quality management system) will come into effect (Nishizawa, 2003).

Trading to maintain the cap is considered a significant strategy for Chesapeake Bay. Some of the Bay jurisdictions actually began to explore trading on their own. Virginia’s legislature enacted the Virginia Water Quality Improvement Act in 1998, which includes a clause requiring trading to be explored as a means of nutrient management (Wiedeman, 2001). Other States proceeded to analysis of the trading market (Maryland) as well as consideration of pilot projects (Pennsylvania) (Nishizawa, 2003).

In 1998, the Chesapeake Bay Programme formed the Nutrient Trading Negotiation Team, to explore trading in the Chesapeake Bay. The team had to examine the concept of trading in the Bay and develop nutrient trading guidelines to assist States in voluntarily developing State-specific nutrient trading programmes. The Negotiation Team focused mainly on the 6 following elements, which are vital to the trading framework: the nutrient reduction goals, eligibility of credits to trade, trade administration, accountability, indicators for assessment of the scheme, and stakeholder involvement (Wiedeman, 2001). According to the fundamental principles on trading that the Team formulated, trading will be allowed only within each major Bay tributary among all signatory States to the 1987 Bay Agreement, as well as non-signatory States if they are consistent with the trading guidelines (Nutrient Trading Negotiation Team, 2001). The nutrient-trading programme should also be consistent with the Chesapeake Bay Programme’s reduction goals, i.e. 40% reduction. To achieve this, trading should be allowed only among “like” sources until the 40% cut-back goal is achieved, which means trading between point and non-point sources is not allowed. However, once the goal has been reached, point non-point source trading will be permitted, and can prove useful in sustaining the target level. The trading programme should set specific nutrient load allocations for each major Bay tributary, a baseline and a cap, as well as allowances for point and non-point sources. The final Nutrient Trading Guidelines of 2001 are available for use by States on a voluntary basis to design their own trading programmes (Wiedeman, 2001). It is considered that many point sources will be able to generate credits for trade, since there are 347-point source wastewater treatment plants in the Bay watershed. Each trade should result in net reduction in nutrient loading and also maintain the tributary nutrient cap. No local water quality impacts are allowed to result from trading. A source may receive credits for reductions in nutrients, through the operation of a facility or the implementation of a BMP (Nutrient Trading Negotiation Team, 2001).

As far as administration is concerned, each State should be responsible for programme oversight and day-to-day management (certification, registration, monitoring, evaluating). A central State coordinating office should be established in each State to deal with the administration of trades. Trades should also be governed by a State general regulation under the State's water quality law, and public participation prior to the execution of a trade should be promoted (Nutrient Trading Negotiation Team, 2001).

The experience from the Chesapeake Bay Programme showed that public involvement and stakeholder participation are key to reaching overall consensus on trading programmes. In the context of the Chesapeake Bay Programme, a long negotiation process took place to develop principles and guidelines for nutrient trading accompanied by a series of public workshops to explain and discuss the draft principles (Nishizawa, 2003).

LESSONS LEARNED ON TRADABLE WATER POLLUTION RIGHTS

This section aims to draw some general lessons learned from the international experience presented on tradable water pollution rights (for salinity, organic pollution and nutrients).

Overall, as it is obvious from the examples of tradable water pollution rights presented above, trading has been applied effectively only to pollution covered by a single chemical or (in the case of electrical conductivity) a single physical parameter. This does not mean that only pollution by identical substances is traded, as the parameters used often refer to classes of substances, such as soluble salts or substances oxidized by by bio-chemical processes. However, in the case of nutrient pollution single elements or substances are the objects of trading (e.g. phosphorus loads).

Experience with salinity trading so far has been rather limited with the most prominent examples existent in Australia. The examples show such trading to be highly intertwined with traditional environmental management systems and strategies. Good scientific understanding of the catchments in question in this case has supported the establishment of trading regimes. Trading is facilitated by the fact that salt pollution can be measured relatively easily, and on a continuous basis. In effect, monitoring the behavior of the market participants is relatively cheap. Moreover, the practical examples given may be useful in designing tradable permit systems for other high profile pollutants, for which continuous analysis may be possible like in the case of salinity.

Experience with organic pollution trading has so far not been very encouraging as illustrated by the case study on the Fox River in the US. However, it appears that this is largely due to a lack of understanding about abatement technologies (and their costs) when the permit trading system was established (Kraemer and Banholzer, 1999). Nevertheless, tradable permits for organic pollution could create an incentive for polluters to identify further possibilities for abatement not apparent to the command-and-control regulators, and therefore not attainable within the existing regulatory regime (Smith, 1999).

Regarding nutrients trading, the experience has been most successful within the conceptual framework of a “bubble” over point sources. In such a context and given that nutrient abatement is largely dependent on up-front investments in treatment systems, trading becomes a tool for allocating and optimizing investment. The system of tradable nutrient pollution permits is underpinned by strong (and pre-existing) regulatory regimes, which provide a framework, including sanctions on individuals for overall failures in pollution abatement.

In the examples presented in this paper, nutrients are not normally a pollution problem of short duration or local extent. This is because their levels in effluents and initial receiving waters have usually already been reduced to levels where no immediate effects occur. Instead, they often have effects over long distances (such as in estuaries or marine basins far away from the average point of discharge, e.g. Chesapeake Bay), or they affect the long-term quality of water bodies, such as lakes used for drinking water production (e.g. Lake Dillon). Because of this, nutrients remain a focus of water quality management and may even become a more interesting field for applying tradable permits in the future.

In the context of nutrients trading, there is also scope for trades between point and non-point (or diffuse) sources. As obvious from the cases presented, although this type of trades (point-non-point) needs further investigation, it is increasingly being practised and further promoted. Environmental protection measures have succeeded in reducing point source pollution in many countries while non-point pollution is gaining in importance. As a result, trades between point and non-point pollution now offer themselves as potential policy measures, especially since reducing non-point pollution is often more cost effective in meeting quality objectives than additional investment in point-source control (e.g. case of Tar-Pamlico). However, looking at the relevant experience in the US, the development of emissions trading for nutrients control has had mixed results partly due to the difficulties in addressing non-point source pollution. The difficulties in controlling non-point pollution through trade stem from the need to consider other complexities in the design of a scheme. Problems arise through the uncertainties in estimating and monitoring non-point source loads as well as due to lack of direct comparability of point and non-point pollution, since non-point discharges may depend on weather events, for instance (Kraemer et al., 2002). To address uncertainty with nutrient reduction from non-point sources, a trading ratio or discount factor is commonly applied to non-point source reductions, as in the case of the Lake Dillon in Colorado.

The lessons drawn here are based on the selected examples from the international arena and they should be considered within the institutional and existing regulatory context of the countries in question, i.e. US and Australia. Both countries had a functioning regulatory regime for water pollution control prior to the introduction of trading schemes. It should be kept in mind that the (institutional and regulatory) context may be different in other countries or regions where trading schemes are being considered. Therefore, one should pay attention not only to the experience with the trading schemes *per se* but also to the pre-conditions, which may have facilitated or impeded trading. The remaining sections of this paper further discuss strategies and relevant factors for the introduction of tradable permits schemes.

APPLYING TRADABLE POLLUTION RIGHTS IN WATER MANAGEMENT

Strategies for Introducing Tradable Pollution Rights Regimes

OECD (2001) discusses extensively the principal issues that arise when designing a tradable permit system for natural resources within a country. For information on the overall design and implementation of tradable permits for environmental management, the reader should refer to this OECD study, which among others indicates the parameters and variables that administrative and political decision-makers are recommended to take into account. Based on the general framework for the design and implementation of tradable permits, this section focuses on the specificity of water pollution trading. Outstanding issues that should be considered for the introduction of tradable water pollution rights and relevant regulatory aspects are discussed.

To start with, experience shows that an existing functioning system of water pollution control should be in place before introducing a market for tradable pollution permits. Such an existing system can be either based on command-and-control instruments or other "less sophisticated" market-based instruments such as charges. An existing functioning system implies that a monitoring system is already established and can provide reliable information/data on pollution loads, which is essential also for trading. Additional to good monitoring, penalties for non-compliance must be immediate and high to ensure enforcement. In a trading system, participants will buy rights if they think violation would be a more costly alternative.

Further, strategies and sequences for the introduction and promotion of trading to control water pollution may be designed making use of various "instrument mixes". Actually, there is a need for compatibility and coexistence between tradable permits and existing regulatory instruments, in order to overcome the various forms of opposition that innovative policy may encounter (Smith, 1999). Issues of compatibility and coexistence of instruments are extensively discussed in section 0.

In general terms, several elements and factors should be discussed during the planning phase of a tradable pollution rights programme, namely the kinds of pollutants that can be traded, the geographic scope of the scheme, the eligibility criteria of the participants entering the scheme, the types of trade desired (including point, non-point sources), any trading ratios that may be appropriate in case non-point sources are included in the scheme (Nishizawa, 2003). A pilot phase for testing the trading scheme may be very useful for exploring and dealing with all relevant issues before proceeding to nation-wide application.

The first step for the actual introduction of tradable discharge permits would be to shift from technology controls on water pollution (which are actually rather rare), and towards controls on emission. At the same time, water use permits should be linked to environmental quality objectives, and water pollution permits should be based on loads, rather than on concentrations. Care must be taken, however, to protect the water environment and other water users from the acute effects of excessive concentrations of pollution due to trades ("hot spots"). The first step requires the emergence of effective controls on the quantity and quality of the effluents discharged, and the receiving waters themselves. The monitoring system would need to be designed to provide data of such quality that they can be used in court for the resolution of any conflicts arising from the use (or abuse) of tradable water pollution rights (Kraemer and Bahnholzer, 1999). Regulators must provide safeguards to ensure that overall environmental quality is maintained or enhanced while preserving the flexibility necessary for pollutant trading. To avoid highly degraded localized areas, trading programs must consider the location of potential partners in the watershed, the size of the watershed where trading can occur, compliance records of trading participants, as well as enforcement and monitoring issues (National Wildlife Federation, 1999).

A second step necessitates the definition of tradable rights, which may vary across different types of pollution. If the system requires emissions to be measured, the conditions under which these measurements take place need to be defined and standardized. If emissions levels of individual firms are already monitored in the context of regulatory enforcement, it may be possible to adapt existing measurement procedures for the introduction of a trading system (Smith, 1999). From a regulatory perspective, it is common practice to establish a cap on total emissions from a defined set of sources, which then allows participants to meet the cap via market mechanisms. The establishment of a pollution cap can be the first step for developing a trading programme; the cap then reflects the maximum amount of pollution the system can safely absorb.

Once the tradable rights are defined, they need to be initially allocated, and a mechanism for allocation be established. The definition and allocation of tradable rights needs to take account of the economics of water use and pollution control, as well as to anticipate the responses of water users to the establishment of a tradable permit regime. The scheme should be designed so as to involve a sufficient number of potential buyers and sellers. There must also be sufficient room and opportunity to correct errors and to “fine-tune” the allocation of rights, as well as the trading rules. Furthermore, the role of environmental and market regulators needs to be defined, and rules for enforcement and sanctions need to be established. In case trading includes non-point sources, difficulties with the enforceability and monitoring of non-point source controls should be overcome before proceeding with trading at a large scale. There is in most cases no regulation for non-point sources and therefore no clear baseline against which to measure emissions reductions, nor is there an understanding of how to monitor, enforce, and evaluate these polluting activities (Boyd et al, 2003). If non-point sources are included in the trading scheme, regulators must consider the uncertainty introduced into the trading pool; lessons can be learned from the case of the Lake Dillon where a trading ratio between point and non-point sources was introduced (a point source had to reduce two tons from non-point sources before it could increase its own discharge by one ton).

Once a tradable permit regime is functioning, its continued ability to meet environmental and resource requirements must periodically be evaluated, including its ability to respond effectively to new (emerging) challenges. The regime should also be adaptable to account for changes in the boundaries of the system, such as an expansion of the territorial coverage and the emergence of unforeseen long-distance effects (Kraemer and Bahnholzer, 1999). However, it needs to be considered that in order to guarantee security for tradable rights and therefore willingness to trade, it is not advisable to unexpectedly revise the rules of the game; it is advisable to avoid revising the rules in a way that might jeopardize investments already made or might extensively challenge the value of permits. As part of a compromise between permit security and programme adaptability, it is proposed to specify beforehand the conditions under which the rules of the game may be changed in terms of timetable, changes in caps and baselines, rules for the allocation of rights or an extension of the scheme (OECD, 2001).

It is also important that "ground rules" about the relationship between trading and regulatory limits be made sufficiently clear at the start of the system. Otherwise, potential participants in trading may be discouraged for fear that trades could affect their subsequent treatment by the regulatory authorities (for instance, in the case of the Fox River, the relationship between trading and regulatory limits was not made sufficiently clear at the start of the system) (Smith, 1999).

Opportunities and Limitations

Additional to strategies for introducing tradable rights for water pollution control, this section emphasizes factors, which may favor or impede the introduction of tradable pollution rights regimes. It partly draws on the experience of the case studies presented in section 0.
Among the key factors favoring trading are the following:

- Assurance and acceptance of rights in emissions and the accompanying trading rules are, next to an effective administrative and legal system, seen as a prerequisite for a functioning trading system. Assurance that the scheme will continue to function can be promoted through the legal establishment of a scheme or other form of stable framework and rules of the game. It is particularly advisable to avoid revising the rules in a way that might jeopardize investments already made or might extensively challenge the value of permits.
- Monitoring and reliable data are part of a solid basis for trading for various reasons including enforcement mechanisms, information for conflict resolution, trade facilitation and program evaluation.
- Clearly defined units of trade have proved important for setting up and running a trading programme of emission rights.
- A thorough pilot phase for testing the rules and conditions of a trading scheme as well as opportunity for consultation with potential participants can be vital for the acceptability and success of a scheme (see case of salinity trading in Hunter River in Australia).
- Solid scientific understanding of the pollution factors and the behavior of the catchment in question has obviously contributed to the functioning of most successful schemes with water pollution trade so far.
- Trading can be stimulated when the market advantage is obvious to the trading participants. For instance, the control of non-point sources is significantly cheaper than of point sources. Point sources can thus pay non-point sources (cheaper control) to abate water pollution.

On the other hand, a number of factors inhibit water trading, or the establishment of tradable permit regimes in water management:

- Numerous administrative requirements, long approval procedures and restrictions to trade may reduce willingness to trade.
- There can be technical obstacles for the establishment of trading for water pollution control when there is insufficient knowledge of the behavior and changes in the pollution load of the water system in question.

- Uncertainty about the legal viability of the “rights” created by tradable pollution permits (see case of Fox River and legal challenge of trading when compared to the Clean Water Act). For instance, the extent to which the reallocation of polluting emissions through trading is compatible with other existing legislation may not be clear.
- The effects of water pollution are not independent of where and when this use occurs. Any trading which shifts water use in space or time has to account for the consequences on other water users or ecosystems. Trading of pollution rights can lead to so-called pollution “hot spots”. While this does not make trading an impossible proposition, it may constitute a severe restriction in certain situations.
- Water trading for water pollution control, as much as for water abstraction, can only occur within restricted geographical zones with common ecological and institutional significance, such as sub-river basins regulated by appropriate water institutions.

The relative importance and consequences of all the above factors need to be assessed in each case where existing water trading is analyzed, or where the establishment of tradable permit regimes is being contemplated.

Compatibility of Tradable Pollution Permit Regimes in Instrument Mixes

Water resource protection and management involves in most cases the use of diverse instrument mixes. This section explores in how far tradable pollution rights are compatible with other important water management instruments (e.g. with taxes and charges or with established principles of environmental policy) and how they can be integrated into the water management, monitoring and enforcement systems already in place based to a great extent on the relevant discussions of Kraemer and Bahnholzer (1999).

Compatibility with taxes and charges

Taxes and charges on water pollution are widely-used policy instruments in water resource protection and management. In addition, there are normally also financial charges for water services, notably water supply (incl. storage) and sewerage services. Water pollution taxes or charges are normally based on the pollutants contained in effluent reaching the water environment.

One of the problems with tradable permit regimes in water management is that, in some cases, the holders of rights are unaware of their entitlement, or cannot be encouraged to trade. Imposing a tax or charge on “sleeping” water rights may effectively induce owners to sell their unused water rights. A combination of tradable permits with taxes or charges can have a number of other positive effects:

- It can help “sleeping” holders of rights to learn about the entitlements they own, thus reducing the cost of entry into the market.
- It may impose a cost on speculative banking of rights, with its attendant risks for water resource protection and management over time, and could have positive consequences for the acceptance of tradable permit regimes.
- It can earn an environmental (or resource) rent that can be employed to carry out water management functions that are in the public interest, thereby redressing persistent environmental or resource externalities.

- It can induce the owners of rights to consider whether or not they need the whole entitlement, or only a part of it, thereby inducing them to place fractions of their entitlements on the market. This would lower the minimum quantity (and value) of trades and supports the formation of marginal prices (market creation).
- By imposing a cost on the difference between the number of rights held and the actual usage, taxes and charges can set an additional incentive to reduce pollution, as any unused right then carries a price. In this way, a combination of tradable rights and taxes or charges can stimulate innovation and even facilitate the "claw-back" of unused rights for new auctions (thereby further lowering barriers to entry).

Taxes and charges, if applied in combination with environmental standards expressed in limit values for concentrations or loads of pollutants, have a significant capacity-building effect, both within the environmental enforcement agencies and with polluters (Kraemer, 1995c). This effect is mainly due to the information flows necessitated by economic instruments, as well as to the incentive function. In light of the above list it would seem plausible to conclude that tradable permit regimes and taxes or charges can be mutually-reinforcing.

Compatibility with environmental quality objectives (EQO)

Environmental quality objectives (EQO) are one of the most widely-used instruments in water resource protection and management. EQOs are conceptually equivalent to "bubbles" and are not only compatible with tradable permit systems, but may even be considered a prerequisite in some cases. However, EQOs are not normally applied on their own, but are usually in conjunction with a range of other instruments of monitoring and enforcement, with which they are compatible. This does not mean that these other instruments, some of which are addressed below, are themselves always compatible with trading within "bubbles".

Compatibility with technology-derived standards (BAT)

Technology-derived standards, usually applied to pollution abatement and control, are often seen as being inefficient, because they require the same abatement standard from every polluter without regard to marginal abatement costs (or benefits). In addition they are often seen as being incompatible with tradable permit systems. The assumption behind this assessment is that technology standards (a prescription on abatement technologies to be used) and technology-derived standards [e.g. pollution abatement parameters such as emission limit values or a reduction percentage set with reference to the "best available technology" (BAT)] are static, and cannot therefore accommodate the economically and environmentally beneficial changes in pollution abatement that tradable permits might induce.

In fact, the approach of using technology-derived standards aims at establishing a dynamic process of continuous improvement in environmental performance. In principle, environmental (emission) standards are expected to follow technological development, and to provide for an ever-higher level of environmental protection. By setting standards on the basis of BAT or some similar definition, regulators force all polluters with similar process or abatement technologies to meet the same standards for new installations. Normally, existing or "old" installations may be operated under previous, less stringent standards until the end of their license period, which should coincide with the

end of their economic or technical life. Any installation built (and operated) later would then have to conform to the BAT in force at the time.
In principle, it would be feasible to combine dynamic technology-derived standards with tradable permits, as in the following scenario: at a time when the best available technology changes, old installations are given a derogation period during which they may continue operation, provided they hold permits to pollute. Such permits, which could be discounted each year by 10 per cent of the original entitlement for instance, might then be sold by those polluters who install better pollution control equipment (or shut down operations) to other polluters who choose to continue operating their "old" installations. Such systems could be introduced each time there is an improvement in the BAT, or when a significant difference develops between the BAT and the (more stringent) "state of the art".

Compatibility with established principles of environmental policy

Tradable permit systems for water pollution control appear to be compatible with the *polluter-pays* and the *resource-user-pays* principles, in that they impose a cost on water pollution, or generate a reward for pollution abatement. Nor should there be any fundamental problems with the principle that pollution effects should be prevented at the outset, rather than mitigated later by compensation measures (prevention principle). Some countries also subscribe to the "minimization principle", according to which pollution should be reduced even if no risk is demonstrated, as long as this is economically-bearable. This principle is best applied through emission limit values, which may be based on technology standards and, as discussed above, which may be combined with tradable permit systems.

The compatibility of tradable permit systems with the principle that pollution should be reduced at source (rather than after dilution) appears to be weak. However, a successful tradable permit system would direct resources at those sources of pollution where abatement is most cost-effective, resulting in an optimal level of pollution reduction at source. In this sense, tradable permit systems *are* compatible with this principle, if "source" is understood to mean the sum of all sources (of similar characteristics).

An important tenet of environmental policy is that action should be taken to reduce risk as soon as there are reasonable grounds to assume that a pollutant may be dangerous or hazardous (*precautionary principle*). According to this principle, action may be taken if a risk is demonstrated in the absence of a conclusive proof of causality (which may be impossible to provide at the level of certainty usually expected in the natural sciences), and before the associated risks can be fully assessed in terms of probability and likely damages (in nature, value, and variance). The precautionary approach may call for significant changes in pollution control as a consequence of new scientific insights. Care must be taken in the design of tradable permit systems to ensure that they provide the necessary flexibility to react to new challenges, since they might otherwise be incompatible with the precautionary principle.

Tradable pollution permits within instrument mixes

It is obvious from the previous discussion that tradable permit systems for water pollution control are, on the whole, compatible with most existing environmental policy principles and instruments. It should therefore be possible to integrate tradable permit systems into existing instrument mixes in a strategy of gradual improvement in environmental monitoring and enforcement practices. It should be perhaps emphasized that, due to their nature, a tradable permit system is a more demanding instrument in terms of enforcement, effective monitoring and a system for settling disputes than other economic instruments for water pollution control.

CONCLUSION AND OVERALL ASSESSMENT

This paper has provided a conceptual framework for the use of tradable permits in water pollution control based on a selection of practical examples from the international arena. It aimed to stimulate discussions at the Technical Seminar on the Feasibility of the Application of Tradable Water Permits for Water Management in Chile on 13-14 November 2003 in Santiago de Chile (organized by the Inter-American Development Bank (IADB) and the National Environment Commission of Chile (CONAMA)). In this final section, we draw general conclusions based on the conceptual framework presented as well as more specific conclusions on the case of Chile.

The paper has highlighted issues, which should be carefully considered for the planning, design, and implementation of tradable emissions permits for water pollution control. A legal framework establishing a trading scheme is desirable since it provides security for trading and clear definitions. However, legal frameworks should be linked to the practical realities of individual countries and regions and should bear in mind issues such as credible enforcement and existing infrastructure (both administrative and technical). The roles of administration should be clear to avoid overlapping mandates that could lead to long tedious approval procedures for trades. Even more importantly, a well-designed monitoring system should be in place to provide water quality data for the trading programme, as it has been obvious from the practical examples presented in this paper. Pre-existing problems of enforcement, for instance linked to standards for pollution control, should be settled before introducing the possibility of trade. It is expected that trade can only function and contribute to the improvement of water quality when it is considered a cheaper option, i.e. cheaper than the violation of a permit limit.

The international experience shows that there are so far a few examples involving tradable permits for water pollution control. It can be argued that markets in water pollution permits are still in their experimental phases. Due to limited experience, there has also been limited discussion so far about the effects of water pollution rights trading on the effectiveness of environmental regulation. In particular, there appears to have been little discussion to date on the possibilities of combining emission standards with tradable pollution permits, or on the monitoring and adjustment needs where tradable permits are combined with environmental regulation using environmental quality objectives (Kraemer and Bahnholzer, 1999).

Experience with tradable permits for water pollution control is accumulating primarily in Australia and the US, which are both advanced economies with long regulatory history in water management and pollution control. The introduction of trade for water pollution control has benefited in these cases from solid scientific understanding of the pollution problems in question, existing monitoring infrastructure and enforcement capacities.

Functioning schemes of water pollution trading tend to be intertwined with traditional environmental management systems and strong (pre-existing) regulatory regimes. The latter ensure both the effectiveness and the integrity of trading schemes, by providing a (sometimes threatening) back-up of potential regulatory intervention. In this context, it may be argued that a usual and potentially advisable sequence of instrument use for pollution control is first command-and-control approaches, followed by market-based instruments which are easier to introduce and implement than tradable permits (such as charges), finally leading to the possibility of trading pollution permits.

It is also obvious from the international experience presented that experimentation with water pollution trading has taken place so far only in federal countries (US, Australia). This could be indicative of the flexibility (and freedom) provided in federal structures to experiment with innovative instruments and adjust rules to the specific conditions of individual States. An inflexible national framework could be limiting in this respect.

Considering the conceptual framework of this paper and the discussions at the Technical Seminar of IADB and CONAMA, we would like to conclude with some key observations on the feasibility of tradable emissions permits for water pollution control in Chile.

Firstly, the issue of economic benefits from trading should be thoroughly considered. In order to have a functioning market for tradable discharge permits, enough market participants should exist. In the case of water pollution, this means that there should be many pollution sources affecting the same parameter (e.g. N, P, BOD, salinity) within the same catchment. Moreover, the different pollution sources must have different abatement cost curves so that beneficial trades are possible. The physical geography of Chile, characterized by short and small river catchments, indicates that the 'markets-to-be' for tradable discharge permits may be rather small. Thereby, the constrained market size will most probably lead to a lack of efficiency and low likelihood of trades, as it was partly the case at the Fox River, US.

Secondly, as the international experience has revealed, a well-designed monitoring system is necessary for water pollution trading. An ineffective environmental administration with low capacity for enforcement and monitoring will be limiting in this respect.

It would need to be carefully ascertained whether and to what extent, the above preconditions exist in Chile. Nevertheless, at this initial stage of evaluation, the authors of this paper conclude that Chile does not appear to be a promising case for the application of tradable permits to counteract water pollution. As an alternative, it is recommended that the use of other economic instruments of a less demanding and simple design should be explored for the purpose of water pollution control.

Finally, it is recommended that the draft law for tradable emission permits in Chile be discussed broadly and that stakeholders (industry, agriculture, municipalities) are informed. In this context, discussions and planning exercises should take place involving those that are potential market participants. In other words, it is highly recommended to carry out in-depth pilot studies in selected basins to test the rules and procedures of the planned trading program. The experience from the pilot schemes can then be used as the basis for finalising a functional legal framework. Pilot phases and programmes have proven very useful when planning emissions trading schemes elsewhere so far. Both in Australia (case of salinity trading in the Hunter River) and the US, long-term pilot schemes have contributed to thorough testing of trading rules and have given the possibility for consultation and exchange with stakeholders and potential participants in advance. Early information and clarification of rules and potential impacts of the schemes can significantly improve the efficiency of the formal, legally established scheme.

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