# SOME CONSIDERATIONS IN DEVELOPING A PROGRAMME OF CONSERVATION AND MANAGEMENT OF INLAND WATERS

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## GENERAL INTRODUCTION

A major objective of this meeting is to develop a series of proposals designed to improve water quality in Brazil and which could form the basis of a national programme. Hence we must consider some of the basic requirements which such a policy statement must include.

In this paper I will not attempt an exhaustive review of the subject, I will simply highlight the areas I consider to be important.

The second law of thermodynamics tells us that it is impossible to develop our economies without creating pollution.

Conservation is always a balance between the cost of carrying out the conservation or restoration and the benefit to society. To return all polluted sites to their original, pristine state (particularly at a rapid rate) would cost an enormous amount of money. If the result of such a policy were the loss of your job and the ability to provide for your family you would need a lot of convincing of the benefit to the rest of society and the ecosystem as a whole. Similarly, although it is nice to dream of the world in its pristine beauty, the majority of us would prefer to live in our developed societies rather than in completely unpolluted world with no modern conveniences. If we wish to bring about the improvements in water quality we propose then we, the ecologist, must make the case to society and outline the most cost effective approaches.

Decisions must be made as to where development can be allowed, what extent of pollution is acceptable and which sites should be restored to a previous, better state. Realistic codes of practice must be formulated to allow a reasonable balance between polluting growth and conservation. The understanding of processes driving aquatic systems, which has been acquired by ecologists over many years, must be form the basis of any planning system.

## DEFINING "POLLUTED"

If we are to conserve or restore a body of water, we need a set of objective criteria to form the basis of any decision making system. The first thing we must do is to define "polluted". This may seem trivial but in Brazilian law, for example, pollution is defined as "a prejudicial alteration of the characteristics of water". This is a perfectly acceptable definition. However, it is generally interpreted as an alteration which reduces the water's usefulness to man. The concept is not well developed of an alteration prejudicial to the survival of an aquatic species or to the maintenance of a process which occurs in the water. Without the legal acceptance of the wider definition nature conservation policies are unattainable.

The definition of pollution must be considered in two parts:

1) how does the substance pollute, i.e. what is its effect;
2) what quantitative level is considered to be polluting.

In answer to the first part let us consider two simple examples. If a high carbon content effluent (e.g sewage) were allowed to discharge into a river so that much of the oxygen disappeared for several kilometres down stream there would be an obvious polluting effect. Conversely let us consider a situation when an effluent with a significant ammonium/ammonia concentration is discharged into a river or lake which is consistently below a pH of about 6 (such as some of the Amazonian streams). The form of ammoniacal nitrogen which is toxic to fish is gaseous ammonia. At pHs below 6.5 only a very small proportion of the ammoniacal nitrogen is in the gaseous form (BALL, 1967).

In this situation is the effluent polluting? Would there be any benefit in reducing the N content of the effluent, unless it were at a very high concentration? (In a full consideration of the polluting effect of ammoniacal nitrogen its oxygen demand would also need to be taken into account).

The level at which a substance is considered polluting depends on the effect it has. There are several ways in which a polluting concentration can be defined. Some of the possible standards are:

1) a (semi arbitrary) chemical standard of acceptable levels of pollution, e.g., the oxygen in the river must not fall below 95% saturation. This approach is simple to administer but it can lead to unnecessary expenditure, for example, a national requirement for a fixed, maximum P concentration in all effluent discharges would lead to unjustified expense where natural phosphatic rocks occur so that available P levels are normally high in rivers and lakes.

2) a biological standard. They have the advantage of being integrating pollution monitors responding to all pollutants.

Chemical monitoring, on the other hand, only gives information on those parameters for which chemical analyses are made, and, even for the analysed determinands, only at the time of sampling. A major difficulty is the identification of unbiased indicator organisms. Early work in the UK was carried out by HYNES (1960). He identified the invertebrate communities which occurred in unpolluted sites. By comparing communities found at other sites with these reference communities, an index of pollution could be obtained. However, more widespread use of these biological indices of pollution showed that they were not applicable to some sites, particularly lowland rivers. This was a result of the original choice of unpolluted sites. Because of the heavy industrialisation of Britain the "unpolluted" sites were all located in low ionic strength, highly oxygenated, fast flowing upland streams. In retrospect it was not surprising that these communities were not the communities expected in the high ionic strength, slow flowing, less oxygen rich lowland rivers.

More recent work (WRIGHT et al., 1989) has used a series of predicting parameters, including altitude, distance from source, substratum type, slope, discharge, mean air temperature, chloride, alkalinity, total oxidised nitrogen, mean water width and mean water depth to predict an expected faunal community for any given site in the UK, against which observed communities can be compared.

3) a standard defined by the quality requirements of the proposed use of the water. Examples of uses would be: hydroelectric power generation, water supply, irrigation, amenity, conservation area.

The water quality requirements for water supply would obviously be the highest. WHO (1985) has published recommended maximum acceptable pollutant levels. Water for irrigation can be of very poor organic quality (oxygen demand or algal biomass) but certain pollutants such as boron will limit the use to certain crops, while other pollutants, such as herbicides, would exclude the use completely. Hydroelectric power generation has no quality requirements at all, as long as the turbines are not blocked. However, uses downstream would also need to be considered and, in any mixed use requirement the highest quality requirement defines the acceptable level of pollution.

4) a standard defined by an acceptable polluting (or critical) load. A typical example is the ability of running water to convert organic pollution to $CO_2$. As long as the organic load is not too high and the reaeration rate is good then the water can absorb some pollution with no detrimental effect. However, setting standards by this method requires a good knowledge of the processes involved and the causes of variation in the rates of pollutant reduction between sites. My own feeling is that several of these standards are required to provide the necessary flexibility to achieve water quality protection at a reasonable cost.

## THE REQUIRED IMPROVEMENT

We then have to decide what point we wish to move to in any improvement. This will usually be defined by the definition of pollution and will not be the same as its original pristine state. In the case of the restoration of an area for the conservation of a particular species or aquatic ecotype, it may be necessary to use paleolimnology to establish the quality of the water in its pristine state.

Whatever the target quality, I firmly believe that any proposed change must create a significant improvement to be worth while. This is particularly relevant in a country like Brazil, where the interest payments on its debt absorb so much of its national wealth.

## MANAGEMENT POLICY CHOICES

We then have to advise on appropriate policies to achieve the change we want to make. In the northern temperate regions we are moving towards a stage where we can begin to manipulate some processes within lakes and rivers to achieve the quality of water we want. This requires either a good understanding of the processes involved in the uptake of pollutants and their removal from the system into permanent or pseudopermanent sinks (e.g. carbonaceous pollution in rivers or lakes requires a knowledge of the rate of reaeration; for heavy metal contaminants, or radionuclides, we need to know the relative rates of adsorption to particles and to sediments, compared to hydraulic retention times) or the availability of large scale survey data to develop regression equations which can be used for prediction (e.g., for eutrophication studies, in northern temperate situations relationships such as those of VOLLENWEIDER & KEREKES (1980) would be used).

Unfortunately many of these are either not applicable to tropical and sub-tropical systems; or their general applicability has not been tested in tropical situations. A significant amount of research work is required to establish appropriate procedures for the tropics.

## LOOKING FOR CHANGE

Finally, whatever the definition of pollution, there must be a series of monitoring programmes, against which the effectiveness of regional and national water quality improvement programmes can be judged. A good discussion of the philosophy of monitoring programmes for UK waters is given by the NATIONAL RIVERS AUTHORITY (1991).

## CONCLUSIONS

Alongside the general definition of pollution in law, any program of water quality management must include four components:

a quantitative definition of unacceptable pollution; a means of defining the required state of the water: mechanisms for defining and choosing between the available management options in order to attain the required water quality and a system of monitoring to assess the effectiveness of water quality policies.

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