Water quality management in the RSA: Preparing for the future†

W van der Merwe and DC Grobler*
Department of Water Affairs, Directorate Water Pollution Control, Private Bag X 313, Pretoria 0001, South Africa.

Abstract

The uniform effluent standard approach is presently used in the RSA to control pollution from point sources. Water quality in the RSA is gradually deteriorating and social and economical changes taking place affect water quality and the way in which it is managed. A new approach, which combines the receiving water quality objectives and pollution prevention approaches, will be used in future to control pollution from both point and non-point sources. The receiving water quality objectives approach to control input of non-hazardous pollutants and the pollution prevention aproach to control input of dangerous or hazardous substances to the water environment will be used.

Introduction

Water quality management in the RSA started with the Union Health Act 36 of 1919, which gave the Chief Health Officer of the Public Health Department the responsibility to control pollution by ensuring that 'the best known or the only or the most practicable methods' for sewage disposal were being used. This allowed the Chief Health Officer to prevent the disposal of effluent from sewage treatment works into water courses. The promulgation of the Water Act, 54 of 1956, and later amendments, notably the Water Amendment Act, 96 of 1984, broadened water quality management. Industrial effluent, and sources other than effluent, e.g. water which arises as a by-product from industrial and mining activities and seepage or storm-water runoff from a site, were made subject to pollution control regulations. The state was also given powers to counteract pollution before it takes place.

As a result of changing demands the Department is shifting its emphasis from resource development to resource management. This shift in emphasis is also accompanied by a greater awareness of water quality and how it should be managed properly. Water pollution control plays a key role in water quality management. Up to now the Department controlled water pollution from point sources by requiring effluent to meet uniform general and special effluent standards which were set at technologically and economically feasible levels. Relaxation of these standards could be negotiated for periods of time, while technological, economical and sociopolitical issues were considered, often without the benefit of knowing the impacts of the standard or the impact of its relaxation on the quality of the receiving waters.

The uniform effluent standards have now been applied for more than two decades and it is believed that, in general, they have served a good purpose. They limited the rate of deterioration in water quality, focused attention on pollution and resulted in improvements to waste-water treatment technology and water management. However, despite these efforts to control pollution, the quality of our water resources is continuing to deteriorate.

This is clear from e.g. the salinity problems being experienced in the Vaal River system, and eastern and western Cape, severe eutrophication problems in the PWV area and acid mine drainage and sulphate pollution in the Olifants and upper Vaal River catchments.

To counter the deterioration of water quality in the RSA and to meet the challenges of the future the Department is adopting a new approach to water pollution control. In this paper different approaches to water pollution control are described and it is shown how the Department's new approach fits into this framework. Finally some of the initiatives that are being taken to implement the new approach are discussed.

Different approaches to water pollution control

Uniform effluent standard (UES) approach

The UES approach aims to control the input of pollutants to the water environment by requiring that effluent comply with uniform standards. The underlying philosophy to the UES approach is that zero pollution (from point sources) is a desirable, ultimate goal. Therefore, these uniform standards are usually set so as to achieve pollutant concentrations in effluent using the 'best available technology not entailing excessive costs' (BATNEEC) to treat effluent. This approach has been adopted by the European Economic Community (EEC) and also forms the basis of the present pollution control activities of the Department of Water Affairs.

The UES approach to water pollution control has several drawbacks (Department of Environment, 1988). It is focused on effluent and largely ignores the impacts of effluent discharges on water quality in receiving waters. In cases where there are multiple point sources of a particular pollutant, or where there are high background levels arising from non-point sources, the UES approach may fail to protect the quality of water resources. The UES approach is also not necessarily cost-effective because it requires all effluent to comply with the same standards, irrespective of variations in the assimilative capacity of the receiving waters or of the cost involved. It provides no incentive for industry to locate at the most advantageous environmental location. It provides no framework for control of non-point sources and consequently cannot guarantee that quality objectives in receiving waters will continue to be met.

The UES approach has two main advantages. It is simple, more comprehensible and more straightforward for regulators to apply. If standards are revised frequently to incorporate the best pollution abatement technology, it should have the effect of minimising pollution from point sources.

Receiving water quality objectives (RWQO) approach

The RWQO approach to water pollution control involves the

† Revised paper. Previously presented at the Biennial Conference of the Water Institute of Southern Africa, held in Cape Town from 27-31 March 1989.

*To whom all correspondence should be addressed.

Received 20 June 1989

specification of water quality requirements in receiving waters and to control point and non-point sources of pollution to such an extent that these water quality requirements are met. It is based on the acceptance of the principle that receiving waters have a capacity to assimilate pollution without detriment to accepted uses for the waters concerned. The United Kingdom has a well established framework for water pollution control based on RWQO (Department of the Environment, 1988). It was formalised through a system in which the uses for which a water body is suitable are defined. On the basis of these uses, the concentrations of water quality variables in the water body which must not be exceeded are specified. Pollution from point sources is then controlled by setting site specific effluent standards which take into account the contribution of non-point sources and the RWQO. A similar approach, the waste load allocation approach, was developed in the United States of America (Thomann and Meuller, 1987).

The RWQO approach has several advantages. Because it is focused on managing the quality of receiving waters in such a way that there is minimum interference with legitimate uses of those waters, it has to consider both point and non-point sources of pollution. It is cost-effective because, by considering the assimilative capacity of receiving waters for particular pollutants, it minimises the level of control required for adequate protection of water uses. It also provides an incentive for industry to locate where receiving waters are less sensitive to pollution.

The drawbacks of the RWQO approach are that:

- from a regulatory point of view, it is technologically much more demanding because it requires a thorough investigation and understanding of the fate of pollutants in the water environment and their impact on water uses; and
- because it leads to site specific effluent standards being specified, it is also not as straightforward as the UES approach to apply.

Pollution prevention approach

Some pollutants are regarded as hazardous or dangerous because they represent a major threat to the water environment as a result of their toxicity, persistence, and capacity for bio-accumulation. The RWQO approach to managing these pollutants is considered to be inappropriate. It is often difficult to set safe receiving water quality objectives because too little is known about the properties of these pollutants and the potential long-term risk they pose to man and the environment. Therefore, an approach based on limiting or, preferably, preventing their input into the water environment was developed to control the presence of hazardous or dangerous substances in the water environment.

Different strategies were recommended for controlling the input of dangerous substances into receiving waters. In the UK (Department of the Environment, 1988) it was recommended that industries discharging significant amounts of these substances should be required to comply with effluent standards based on BATNEEC. Such industries should also be required to 'carry out all other functions ... in accordance with best practice and in a manner that renders any emissions that do occur harmless and inoffensive to people and the environment as a whole'. In the United States (World Environment Centre, 1985; US EPA, 1988), concepts of pollution prevention and waste minimisation were introduced to control inputs of dangerous or hazardous substances to the water environment. These concepts focus on source reduction and recycling to minimise wastes and can involve reduction of the quantity of waste or reduction of the toxicity of the waste, as long as it minimises present and future threats to human health and the environment.

New approach to water pollution control in the RSA

Major economical, political, social and demographic changes are taking place in the RSA. For example, our economy seems to be changing from one being dominated by a few large enterprises to one in which the informal sector and small businesses will play an increasingly important role. Changes are taking place in urbanisation patterns. The traditional high-cost low-density urban developments, which catered for the needs of the white population group, have been overtaken by development of large low- cost high-density urban areas to cater for the rapid urbanisation of the RSA's growing black population. These changes have impacts on water quality. For example, typical high-cost low-density urban areas have sophisticated waste management systems (sewers, sewage treatment plants) that act mainly as point sources of pollution which can be controlled easily. In contrast, some of the low-cost high-density urban areas have unsophisticated waste management infrastructure (e.g. pit latrines) and act mainly as non-point sources of pollution which are difficult to control (Ashton and Grobler, 1988).

Faced with the gradual deterioration of water quality and the expected changes described above, the Department decided to adapt its approach to water quality management to ensure that it will continue to meet its obligation namely: 'To ensure that water of an acceptable quality for recognised water uses, such as urban, industrial, agricultural, recreational and environmental conservation uses, continues to be available' (Department of Water Affairs, 1986).

In reviewing its pollution control activities the Department has stated several principles which form the basis of its new approach. These are:

- The desired quality of a water resource is determined by its present and/or intended uses. This quality should be stated as a list of water quality objectives.
- It is accepted that the water environment has a certain, usually quantifiable, capacity to assimilate pollutants without detriment to predetermined quality objectives.
- The assimilative capacity of a water body is part of the water resource and, as such, must be managed judiciously and shared in an equitable manner amongst all water users for the disposal of their wastes.
- For those pollutants which pose the greatest threat to the environment, because of their toxicity, extent of bio-accumulation and persistence, a precautionary approach aimed at minimising or preventing inputs to the water environment should be adopted.

The Department's new approach to water pollution control combines the RWQO and the pollution prevention approaches. It involves using:

- the RWQO approach to control non-hazardous pollutants; and
- the pollution prevention approach to control hazardous pollutants.

In its new approach the Department also recognises both point and non-point sources as major sources of pollution, both of which

should be controlled. The Department's new approach is similar to the one which is recommended for the UK (Department of the Environment, 1988).

Although a new approach to water pollution control is being adopted it cannot be implemented overnight. The skills, technologies, policies and strategies required to implement the new approach still have to be developed. Therefore, the Department will continue to enforce the general and special standards as it has done in the past, while it is gradually implementing the new approach. The Department plans to consult the water industry in the development and implementation of its new water pollution control policies and strategies.

Implementation of the new approach

Implementation of the Department's new approach to water pollution control requires that several water quality assessment technologies, and the skills needed to apply them, are locally available. Many of these technologies and skills are not well established in the RSA. Therefore, the Department has taken several initiatives, which are described below, to ensure the availability of the required technologies and skills in the RSA.

Water quality monitoring systems

Managing water quality requires information about what the water quality is, how it changes over space and time, and how it responds to management actions, such as pollution control. This information is obtained from water quality monitoring programmes. Although monitoring programmes are ostensibly implemented to provide information required for managing water quality, they seldom achieve this. The remedy is to view, and design, monitoring programmes as information systems (Ward *et al.*, 1986).

The Department operates three major water quality monitoring programmes. Two of these are aimed at determining what the quality of South Africa's surface and ground-water resources are. The third is designed to provide information on water quality in effluent and is used mainly for monitoring compliance to pollution control regulations. Although these monitoring programmes have been in operation for some time, it was found that they suffer from the 'data-rich but information-poor' syndrome which means that they do not meet the information requirements of water quality managers. These water quality monitoring programmes are being redesigned, according to the procedure recommended by Ward (1988), to improve their performance as information systems. It is anticipated that the following monitoring systems will be developed eventually, each providing for the information needs of different kinds of water quality management activities.

- ***National monitoring system:*** A national water quality monitoring system will be operated to provide information on what the water quality is throughout the country and how it is changing. It will specifically avoid trying to provide information on why the water quality is what it is.
- ***Catchment monitoring systems:*** Catchment-specific water quality monitoring systems will be operated to provide the information required to manage water quality in a specific catchment. In their design, recognition will be given to water uses, water quality problems, and management strategies which are specific to a particular catchment. These monitoring systems will address the issue of why the water quality is what it is and will provide information on the effectiveness of the water quality management strategies being employed.
- ***Compliance monitoring systems:*** An important part of the Department's overall water pollution control strategy is to enforce effluent standards. A monitoring system for assessing compliance with effluent standards is required.
- ***Project monitoring systems:*** It is realised that none of the monitoring systems mentioned above can completely satisfy the information needs of specific water quality investigations or research projects. If such an investigation requires information which cannot be obtained from the existing monitoring systems, a monitoring system designed to meet its specific requirements must be implemented. Upon completion of such a project its monitoring activities will cease.

To improve the monitoring programmes operated by the Department, it provided for staff straining by sending people to attend a short course on monitoring systems design. The Department's first priority now is to develop the national monitoring system to enable it to regularly report on the status of surface water quality in the RSA. The Department, CSIR and the Water Research Commission are involved in the design of the national monitoring system. The Department is also examining the use of water quality indices for reporting on water quality. It has also started designing catchment monitoring systems for the Hartbeespoort and Vaal Dam catchments and has formed a task group to start working on the design of compliance monitoring systems.

Waste load allocation

The concept of waste load allocation (WLA) is central to the RWQO approach to water pollution control. In principle, WLA is the assignment of allowable discharges to a water body in such a way that the water quality objectives for designated water uses are being met. Principles of benefit - cost analysis are used in these assignments. It involves determining water quality objectives for desirable water uses, understanding the relationships between pollutant loads and water quality and using these to predict impacts on water quality. The analysis framework also includes economic impacts and sociopolitical constraints (Thomann and Meuller, 1987).

There are several factors which hamper WLA investigations to be done immediately on a wide scale. The most important are the lack of skilled people in this field and a lack of locally tested models for simulating the water quality response of receiving waters to discharges of a variety of pollutants. However, the Department has started using WLA investigations to determine allowable discharges from some major industries. In the process the people involved are acquiring the necessary skills and some of the models required are being developed and tested. We foresee a rapid increase in the number of WLA investigations being done, as they form the backbone of the RWQO approach to water pollution control.

Health and environmental risk assessment

The classification of pollutants as hazardous or dangerous, thereby requiring that the pollution prevention approach should be adopted for their control, has to be done on the basis of the risks posed to human health and the water environment. Health and environmental risk assessment concepts were used to compile lists of hazardous pollutants such as the list of 'priority pollutants' in the USA and the 'Red List' of substances in the UK.

Risk assessment is carried out in four steps:

- hazard assessment examines the evidence that a substance detrimentally affects human health or the environment;
- dose-response assessment examines the evidence relating to the dose of a pollutant and its impact on health and the environment;
- exposure assessment identifies the populations exposed and the routes through which they are exposed; and
- risk management deals with the decisions and actions taken to limit risks and communicate risk information to water users.

It is vital to understand how people think about risks, especially in a diverse society like ours. Without such understanding, well-intended policies and actions are likely to be ineffective.

Skilled manpower and the technology needed for risk assessment are required to allow information on risks to be incorporated in our management of dangerous or hazardous substances in the water environment. The Department is trying to promote research and development in this area by supporting research proposals on this topic submitted to research funding organisations such as the Water Research Commission and the Foundation for Research Development.

Policy analysis and development

Economical, social and political changes taking place in our society alter water quality requirements, affect water quality, and have important implications for policies and strategies to control water pollution. These changes and their water quality impacts must be anticipated in time to allow for the development of appropriate policies and strategies to deal with their impacts. Therefore, projections of likely future scenarios are required from which information can be obtained on what type of water pollution problems to expect, and when and where these problems are likely to occur. In this respect, projections of the likely consequences for water quality and pollution control strategies of the rapid urbanisation of our black population and the increasing role of small and informal businesses in our economy are high priorities.

South African society is characterised by its complexity (e.g. different cultures and different standards of living) and the major changes it is undergoing. It may be found that present policies, which are often based on those of highly developed western countries, will not be appropriate for managing water quality in future. Regular review is required of water quality management policies and strategies with respect to their acceptance by different sectors of our society and their effectiveness in maintaining acceptable water quality.

Now that the Department is adopting a new approach to pollution control which accepts firstly that receiving waters have an assimilative capacity for wastes, and secondly that this capacity should be regarded as a resource, what should its policies be regarding the management of this resource? Should it allocate 100% of the assimilative capacity to polluters or should it always allow for a safety factor by never allocating more than say 60% of if? Should all the available capacity be allocated to existing polluters or should some be held in reserve for future allocation? Should it charge polluters for the assimilative capacity allocated to them and if so, should polluters be allowed to trade their allocated capacity amongst themselves?

The Department has requested the Foundation for Research Development at CSIR to initiate a special programme which will address the issues of scenario planning and policy analysis insofar as it affects water quality management in the RSA. It is hoped that such a special programme will contribute to the development of skills required by the Department for reviewing and updating its water quality management policies and strategies.

Water quality management strategies for drainage basins

The Department realises that proper water quality management requires comprehensive water quality management plans for each large drainage basin in the RSA. This was one of the main purposes of regionalisation, and the development of such comprehensive management plans will soon be started in the different regions. The development of these plans requires a thorough understanding of the fate of pollutants in the environment and has to be done by people skilled in both the quality and quantity aspects of water resource analysis. Furthermore, it requires the availability of water quality models that can be used to simulate the water quality response of a complete drainage basin to alternative management options. The models which are presently available can do this to some extent for eutrophication and salinity but need to be extended to incorporate other water quality variables. The development of water quality management plans also requires reliable information on the status of and trends in important water quality variables in these systems. This information is presently unavailable for most drainage basins but will become available as a result of the new monitoring systems which are now being implemented.

Considering these limitations, one may want to put off the development and implementation of water quality management plans for drainage basins until most of these limitations have been overcome. However, the sooner the process is started the better. Although the initial water quality management plans may not be as comprehensive as they should be, they will enable critical shortages in skills, technology and information to be identified, thereby allowing these to be specifically addressed. The development of comprehensive water quality management plans for all drainage basins in the RSA is a major undertaking which will take a long time to complete.

Conclusions

- Up to now the Department has adopted the UES approach to control pollution from point sources. Water quality in the RSA is gradually deteriorating and major social and economical changes, which will influence water quality and the way in which it is managed, are expected. To be able to meet these challenges the Department of Water Affairs is adopting a new approach to water pollution control as part of its overall water quality management strategy.
- In future a combination of the RWQO and pollution prevention approaches will be used to control pollution from both point and non-point sources. The RWQO approach will be used to control input of non-hazardous pollutants, while the pollution prevention approaches will be used to control input of dangerous or hazardous substances to the water environment.
- It is not possible to change immediately from the old to the new approach. Therefore, the enforcement of the present uniform general and special standards will continue, while the skills, technologies, policies and strategies required for controlling pollution according to the new approach are being developed and gradually implemented. The Department plans to consult water industry regularly in the development of its water quality management policies and strategies.
- The Department has already taken several initiatives to implement the new approach. It has started training its own

staff and is encouraging its consultants and others in the water industry to do the same. Water quality monitoring programmes are systematically being redesigned to improve their performance as management information systems. It has started using waste load allocation investigations to arrive at site specific effluent standards based on receiving water quality objectives. It plans to start shortly with the development and implementation of comprehensive water quality management plans for drainage basins. The Foundation for Research Development at CSIR was requested to fund special programmes on risk assessment and policy analysis through which skills in those areas can be established in the RSA.

Acknowledgement

This paper is published in *Water SA* with the permission of WISA.

References

ASHTON, PJ and GROBLER, DC (1988) Botshabelo and the water quality of the upper Modder River. *Proceedings of the Eighth Quinquennial Convention of the South African Institute of Civil Engineers,* held at the University of Pretoria, 4-8 July 1988. Vol. **5A,** (Environmental Conservation), Paper 4.

DEPARTMENT OF THE ENVIRONMENT (UK) (1988) Inputs of dangerous substances to water: Proposals for a unified system of control. The government's consultive proposals for tighter controls over the most dangerous substances entering the aquatic environment ("The Red List"). Department of the Environment, Welsh Office.

DEPARTMENT OF WATER AFFAIRS (1986) *Management of the Water Resources of the Republic of South Africa.* Department of Water Affairs, Pretoria. 3.

THOMANN, RV and MEULLER JA (1987) Principles of surface water quality modelling and control. Harper and Row, New York.

US EPA (1988) The EPA manual for waste minimization opportunity assessments. EPA 600/2-88/025. Hazardous Waste Engineering Research Laboratory, US EPA, Cincinnati, Ohio.

WARD, RC (1988) Water quality monitoring as an information system. Paper presented at the US EPA National Symposium on Water quality Assessment, June 1-3, 1988. Annapolis, Maryland.

WARD, RC, LOFTIS, JC and McBRIDE, GB (1986) The "Data-Rich but Information-Poor" syndrome in water quality monitoring. *Environ. Manage.* **10** 291-297.

WORLD ENVIRONMENT CENTER (1985) Pollution prevention pays. An overview by the 3 M Company (USA) of low and non-pollution technology. World Environment Center Report, New York.