

Education in environmental hydrology: The case for its implementation in the developing world[#]

B Rawlins

Department of Hydrology, University of Zululand, Private Bag X1001, KwaDlangezwa 3886, South Africa

Abstract

The emergence of environmental consciousness in South Africa can be seen as a relatively recent phenomenon that has, in part, been facilitated by an increased global environmental awareness. As a consequence, environmental issues are now taken more fully into consideration in the political, economic and social spheres of the country. This paper shows how these environmental issues contain significant hydrological aspects and how, through the education of hydrologists, policy-makers and the public, the hydrological sciences can play an important role in environmental management.

Introduction

The past few decades have seen a dramatic increase in world attention to the environment. In the main, such attention has emanated from the western "developed" nations, and has been directed on the one hand at local, regional and national issues, and on the other at issues of global concern. Notably absent, however, has been an attempt to address environmental problems in the "less developed" countries. Although accusations have been made, little has been done to guide or help Third World policy-makers achieve a sound environmental status.

South Africa is a particularly interesting case in point, combining as it does different stages of development. From a hydrological review of the local press over the past few years, two trends are apparent: increased environmental awareness, and continued poor environmental control. Events and conditions that have been highlighted include the spillage and discharge of industrial effluent; gross pollution of rivers; the variety of problems associated with large-scale informal settlements; and general catchment degradation. This emergence of environmental consciousness in South Africa has caused environmental issues to be taken more fully into consideration in the political, economic and social spheres of the country. How successful such consideration has thus far been is a matter for debate, but it is heartening to note that at least some progress has been made.

In the hydrological sciences, it is evident that the upsurge in environmental interest has been responsible for a greater public awareness of, and consequently a greater recognition of, the subject. One of the effects is an increase in employment prospects for the hydrological sciences. Associated with this, however, is a need for professional development. In almost every environmental issue that occurs, we witness, through the media, members of the public, government representatives and industrialists stating that the hydrology of the particular issue is important. While this is invariably true, since the protection, conservation and utilisation of the country's water resources is of national importance, there remains a disquieting sense that the term hydrology is either being used just as a buzzword to satisfy those perceived as "radical greenies", or to convey the rather nebulous "scientific"

concept of having something to do with water. Even given such an ill-informed use of the term, the hydrological community should capitalise on the opportunities afforded by heightened public awareness. The external perceptions of our discipline could be considerably enhanced by the provision of a professional service that not only fulfils the requirements of any particular issue, but also broadens the perspectives of those who have access to the completed product. In order to achieve this aim, it is essential that hydrologists, who in practice have come from different scientific backgrounds, have received different training, and have gained varied experience in the course of their careers, are able to perform their duties to the highest professional standards.

Recent developments in hydrological education, though having significant environmental components (Buras, 1991; Nash, 1992; Yevjevich, 1992), have tended to focus more on the status of hydrology as a discipline (Nash et al., 1990; National Research Council, 1991; Rawlins, 1992; Rodda, 1992), and on the pressing problems of water supply and sanitation in developing countries (Pickford, 1991). For hydrology to consolidate its status as a discipline, however, it needs to incorporate current environmental initiatives into its structure and to embark on a planned programme of education in, and application of, the hydrological sciences in this country. In addition, there is a definite need for the community at large to be better informed about the role that is played by hydrology (and by hydrologists) in maintaining the environmental integrity of the country and the planet.

Hydrology in South Africa

Hydrological expertise is of considerable importance in South Africa since water is both scarce and poorly distributed spatially. This (un)availability of water is further complicated by the irregular nature of the rainfall and by high evaporation rates. Seasonally, most of the country receives rainfall only during the summer months followed by a prolonged dry period. The regular occurrence of periods of below-average rainfall, which can last for years, puts further stress on these meagre resources. Consequently, water resources management has, to date, been directed at creating sufficient reservoir storage to enable yields to be sustained over long periods.

The industrialisation of South Africa has thus far proceeded with little regard for the availability of water. For example, the mining base of the economy which is centred around Johannes-

Received 1 March 1994; accepted in revised form 6 September 1994

[#] Revised paper. Originally presented at the 6th SA National Hydrological Symposium in September 1993 in Pietermaritzburg and published in the *SANCIAHS Proceedings*.

burg is not in a particularly water-rich area. Around this area, mining activities have led firstly to the development of allied heavy industry and power generation, and secondly to the establishment of numerous light industries. The corresponding increase in population and in water utilisation has tapped the locally available water resources to the limit. Continued industrial expansion has been possible only with the development of extensive water recycling schemes and the construction of large and costly inter-basin transfer schemes. Decentralisation policies, initiated by the Government in an attempt to alleviate the situation, have as yet met with limited success. Consequently, the major function of South African water resource management has been to meet the rapidly increasing industrial and domestic water demands where and when they occur.

Many of the rural areas of the country are notoriously impoverished and over-populated. As a consequence of *apartheid* policies, many people live in remote areas which are generally deficient in water. Water supply to these areas has been developed only on a small scale, and sanitation technology is often rudimentary. For decades this sector of the country has been largely ignored; with current political changes, however, it is now gaining increasing attention.

The focus of future development of South Africa's water supply should thus be twofold. The urban and industrial centres which have relied on high technology solutions in the past will continue to require "first-world" hydrological expertise, especially in the application of water conservation measures, the recycling of effluent and the development of inter-basin transfer schemes. The rural areas, where it is usually not feasible to use conventional reticulated water and sewage networks, require the development and introduction of alternative strategies to address their water needs.

In order for South Africa to implement this twofold development strategy, personnel trained in many fields will be needed. At present, the small hydrological community is mainly specialised, through training and employment, in addressing "First World" problems. A broader base of expertise is essential.

Environmental hydrology in South Africa

In order to illustrate the current status of "environmental hydrology" in South Africa and the need for fresh directions in the education of hydrologists, policy-makers and the public, this paper focuses on two recent environmental issues that have had significant hydrological components. The issues selected do not cover the entire spectrum of hydrology, nor are they reviewed with anything but an outsiders' perspective. Primary sources are mainly from the local news media. The purpose of the exercise is

to highlight public and press perceptions of the issues, and to assess the need for hydrological education in its broadest sense. Apologies to any of the hydrologists involved for any misrepresentation of their work.

Example 1: Sappi effluent spill - Ngodwana River, E. Transvaal 1989

The following newspaper headlines appeared during the days and months after effluent, consisting of "ligno-sulphates and soap skimmings", from the Ngodwana Paper Mill in the E. Transvaal entered a storm-water drain leading to the Ngodwana river. The compounds were not deemed "toxic" by Sappi, but appear to have been responsible for consuming much of the river's oxygen resulting in the suffocation of fish and other life in the river. Headlines listed begin with the break of the news and continue until the case was resolved several months later.

The initial release of the news of the spill (Table 1) was characterised by extensive use of the words "poison" and "toxic" with a focus on the death of fish and the potential danger to downstream users of the affected river. This initial reaction was tempered the following day (Table 2) by the release of preliminary "official" reactions by the mill owners and the CSIR in which the poisonous nature of the effluent was denied and the water declared safe to drink.

TABLE 1
SAPPI: RELEASE OF NEWS (26/9/89):

Sappi poison kills tons of river fish	(The Star 26/9/89)
Water crisis after poison spills	(Daily News 26/9/89)
Fish gasp after chemical spill	(Natal Mercury 27/9/89)

TABLE 2
SAPPI: OFFICIAL REACTION (27/9/89)

CSIR gives all-clear on polluted river	(The Star 27/9/89)
Mill effluent not poison	(The Star 27/9/89)
Nelspruit river water polluted by paper mill now safe to drink	(Daily News 27/9/89)

In spite of these reassurances, the public and the press continued to react to the event and the issue remained prominent (Table 3). The focus switched from potential danger to life, to the broader environmental effects on aquatic life and the biological

TABLE 3
SAPPI: PRESS RESPONSE (28/9/89 - 3/10/89)

How complacency kills fish	(Editorial: The Star 27/9/89)
Row over Sappi pollution rages	(The Star 28/9/89)
Aquatic life wiped out, shows river of death probe	(The Star 28/9/89)
Sappi effluent spill a tragedy, say officials	(The Star 29/9/89)
Big area of river network destroyed	(Natal Mercury 29/9/89)
Transvaal river "biologically dead" following chemical spill	(Weekly Mail 29/9/89)
Effluent spill: river "ruined"	(Natal Witness 29/9/89)
Water pollution hits 200 000 in Eastern Transvaal	(Daily News 2/10/89)
Sappi employees help clear river of dead fish	(The Star 3/10/89)

functioning of the river as well as potential effects on the Kruger Park. Furthermore, the consequences on upwards of 200 000 people living in the area and using the river water were questioned. Also highlighted was the progress made in cleaning the river and the institution of remedial measures.

The launch of an official inquiry into the spill (Table 4) was also announced in the days following the spill which served both to reassure the public that "something would be done" about the event, and to highlight the legal process involved in such a case.

TABLE 4 SAPPI: LAUNCH OF INQUIRY (29/9/89 - 3/10/89)	
Hey to lead spill inquiry	(The Star 29/9/89)
Police probe launched after rivers are polluted	(Sunday Tribune 1/10/89)
Sappi may face charges over rivers of death	(Sunday Times 1/10/89)
Prosecution coming in Sappi "spill" case	(Natal Mercury 3/10/89)

Following on from the initial response, the next few weeks were characterised by an "open season" on the company responsible for the spill (Table 5). Other plants operated by the company were highlighted and operational procedures called into question. Further reaction in the form of letters from the public both against and for the company occurred during this time.

TABLE 5 SAPPI: INVESTIGATION OF RELATED ISSUES AND LETTERS FROM THE PUBLIC (2-4 WEEKS LATER)	
The Tugela River is next in line	(Sunday Tribune 8/10/89)
SAPPI'S 'SEWER'	(Sunday Tribune 8/10/89)
STINKER SAPPI	(Sunday Times 8/10/89)
Sappi has killed Mandini River, say local residents	(The Star 9/10/89)
Now paper company is planning to dump waste in the Tugela	(The Star 9/10/89)
Sappi "should put own house in order"	(Letter: The Star 19/10/89)
Sappi spent millions pioneering a way to combat mill pollution	(Letter: The Star 30/10/89)

The final episode in this saga, from the press point of view, occurred some six months later with the outcome of the legal case initiated soon after the event (Table 6). A R6 000 fine was imposed on the company and this provoked a derisive response from a number of conservationists.

The sequence of events following this pollution incident highlights the need for greater hydrological and environmental awareness. The initial response of the press and the public was to denounce the perpetrator without full cognisance of the facts, while the perpetrator reacted with an immediate denial of these perhaps unfounded accusations. Analysis of the newspaper articles shows a remarkable lack of input from the scientific community. Though this could perhaps be attributed to the lack of newsworthy or sensationalist revelations, it is more likely due to an

TABLE 6 LEGAL OUTCOME AND REACTION (6 MONTHS LATER)	
Sappi boss fined R6000 over spillage of effluent	(The Star 16/3/90)
Disgust expressed over nominal fine for severe Ngodwana river pollution	(Daily News 19/3/90)
"Nominal" fine on Sappi angers conservationists	(The Star 20/3/90)

unwillingness to make public statements for fear of being misquoted (or wrong). Yet if the scientists, who are probably in the best position to clarify the issues, do not make themselves heard, then neither the press nor the public can be blamed for misrepresenting or misunderstanding the situation.

The educational implications thus brought to light include the need for the hydrological community to adequately inform the public about matters of a hydrological nature; the need for industrialists and developers to be made aware of the potential environmental and hydrological consequences of their actions; and the need for the disseminators of "news" of this type to act responsibly and scientifically in their reporting of events.

Example 2: Umsindusi and Umgeni - Biological water quality (1989-1993)

Over the past five years, much attention has been given to the water quality status of the major water supply rivers feeding the Pietermaritzburg/Durban region. These rivers, in addition to being used for municipal and industrial water supply, also serve as resource utilities for the rural and informal settlements along their courses. Furthermore, through their accessibility to a large population, they are widely used for recreational purposes: most notably at the major reservoirs and most publicly through the holding of the annual Dusi canoe marathon. This latter use has, no doubt, contributed to an increased public awareness and, while this river system is possibly no worse than many others in the region, its water quality problems have received extensive media coverage.

To illustrate the situation, the selected newspaper headlines that follow (Table 7) give a broad perspective on both the problems involved and the efforts initiated to rectify the situation. Of particular interest is the development of the issue as a "story" from year to year. The period immediately before and after the annual canoe race is generally characterised by an increased number of articles. This was especially the case in 1991 when an estimated 90% of the participants in the canoe marathon were reported to have suffered ill-health following their exposure to the river water. The years following 1991 generated a high level of interest even when the incidence of ill-health was minimal (5 cases in 1992). During the remainder of the year, it appears that stories relating to the Umsindusi River water quality occur only when "newsworthy" pronouncements are made, or when reports are released.

The educational focus apparent in this issue is unlike the previous one in that the problems associated with the river system are neither short-lived nor will they fade from public scrutiny over time. Furthermore, there is the very real threat of disease and death associated with the use of water from the system. This threat is likely to escalate with an increase both in the population within the catchment area and in the demands for water from the

TABLE 7
UMSINDUSI AND UMGENI - BIOLOGICAL WATER QUALITY

The poisoned province: Dusi, River of disease	(Sunday Tribune 30/7/89)
City engineer calls for Dusi health hazard signs	(Daily News 5/9/89)
Poor sanitation affects water supplies for 2.5 m	(Daily News 24/4/90)
Population influx sparks major river pollution problem	(Daily News 26/7/90)
Umgeni pollution a "major threat"	(Natal Mercury 25/9/90)
Pollution threat to this year's Dusi competitors	(Daily News 19/1/91)
Dusi paddlers given assurance on pollution	(Natal Mercury 23/1/91)
Gastro-enteritis poses major threat to Dusi canoe marathon	(Daily News 6/2/91)
Probe into pollution of Dusi is continuing: Minister	(Daily News 14/3/91)
R200 m. project to clean up the Dusi	(Daily News 9/4/91)
The dying Dusi	(Sunday Times 28/4/91)
Umgeni Water's attempts to tackle pollution in the Umsindusi	(Letter: Daily News 2/5/91)
The river that's dying of shame	(Natal Mercury 6/5/91)
Cheap toilet could flush away river pollution problems	(Daily News 1/6/91)
Squatters "main cause" of local water pollution	(Natal Mercury 6/6/91)
Call for rural area water plan	(Natal Mercury 18/6/91)
High faecal counts in Umsindusi	(Natal Mercury 28/10/91)
Dusi prosecution "a real possibility"	(Natal Mercury 20/11/91)
Calls for clean up of major Natal rivers	(Natal Mercury 22/11/91)
Dusi . . . if you dare	(Sunday Tribune 1/12/91)
Capital to be prosecuted for polluting Dusi	(Daily News 13/12/91)
Special purification plant to beat "Dusi guts"	(Daily News 17/1/92)
Bacteria count "at record low" this year	(Natal Mercury 22/1/92)
1 334 canoeists poised for a healthier Dusi	(Daily News 22/1/92)
Dusi marathon: big drop in water pollution	(Daily News 29/1/92)
The Dirty Dusi	(Daily News 12/1/93)
Battle to clean up Dusi route	(Natal Mercury 13/1/93)
Dusi should be safe for canoeists: Umgeni Water	(Daily News 13/1/93)
Dusi not under threat, say race organisers	(Daily News 26/1/93)

river system. Education on this issue is required to enable the inhabitants and users of the river water to respect the resource so that their safety and the safety of others is assured. Education initiatives, with extensive media participation, have been undertaken most notably in the creation of Project WATER (Water Awareness Through Educational Response) and in the appointment of education and media officers within the water utility company.

Hydrological education in South Africa

As is apparent from the two cases cited above, public awareness of environmental and hydrological issues has increased over the past few years. Television programmes, magazine articles and the news media have all contributed to this progress, as have the introduction of, for example, "Water Week" and "Environment Day" into the calendar. These developments, allied with the policy of public education by several companies from the private sector in the form of sponsorship and the production of video material, have led to a greater public recognition of our subject. The appointment of educational and environmental officers, and the development of programmes such as "Project WATER" are to be commended.

Within the spheres of education and training, the situation is somewhat different. University departments of agriculture, geography, engineering and geology have developed hydrological courses with different emphases. Until recently, South African

universities have catered exclusively for students with First World backgrounds and aspirations. Course structures have been conventional and similar to those found elsewhere in the developed world. Government departments, notably those responsible for water affairs, forestry and agriculture, have also addressed the need for qualified hydrologists and hydrological technicians by conducting in-house training schemes and encouraging further study. Regular courses aimed at hydrologists and engineers practising in the private sector are also offered by various bodies.

Existing courses, however, appear to focus on training in high technology solutions to complex water resources problems. The need for development and training in low or alternative technology solutions to the problems of the under-developed sectors of the country have been recognised mainly by development agencies but training in these fields has as yet not been implemented on more than a small scale. The formal environmental content of such courses appears to be minimal, and though it would be difficult to exclude environmental issues from the teaching of hydrology, there does not appear to have been a deliberate attempt to highlight environmental issues as an integral component of hydrology as a subject.

Conclusions

Initiatives towards the development of a greater hydrological awareness within the community should thus be linked to a move to increase the environmental awareness of practising hydrologists.

Nash (1992) suggested that this could take the form of emphasising environmental effects, where possible, in all hydrological courses taught, and by ensuring that hydrologists become aware of the environmental impacts involved in their activities. It is, however, recognised that to over-emphasise the environment in hydrology courses could detract from the effectiveness of hydrological training. It therefore follows that a balance should be maintained between the education of hydrologists and the incorporation of environmental aspects into existing courses.

A complementary strategy could take the form of incorporating more hydrological aspects into existing and proposed courses on environmental management and impact assessment. Practising "environmental scientists" have tended to come from the biological sciences, and have had little or no hydrological training. With the introduction of specific environmental courses, the opportunity now exists for hydrology to form a more significant component of such courses, and to contribute to the production of environmental specialists who are trained in hydrology.

The benefits for hydrology and for the broader community, respectively, might be specified as follows. Given a more environmentally conscious hydrological community, it follows that the wider community should benefit from the creation of "environmental hydrologists" or "hydrological environmentalists" since water resources will be managed environmentally and the environment will play an important role in the water development of the country. The opportunities thus afforded for the hydrological education of the community will be capitalised upon and the future prospects for both hydrology and the environment will be enhanced. The country might then be in a position to look forward to an environmentally and hydrologically sound future.

References

- BURAS, N (1991) The need for education and training in geosciences for the development of third world countries. *Water Int.* **16**(2) 59-63.
- NASH, JE (1992) Some musings on hydrological education. In: RAYNAL, JA (ed.) *Hydrology and Water Resources Education Training and Management*. Water Resources Publications, Littleton, Colorado. 478 pp.
- NASH, JE, EAGLESON, PS, PHILIP, JR and VAN DER MOLEN, WH (1990) The education of hydrologists. *Hydrol. Sci. J.* **35**(6) 597-607.
- NATIONAL RESEARCH COUNCIL (1991) *Opportunities in the Hydrologic Sciences (Executive Summary)*. National Academy Press, Washington. 16 pp.
- PICKFORD, J (1991) Training and human resource development in water supply and sanitation. *Water Int.* **16**(3) 169-175.
- RAWLINS, BK (1992) Hydrological education in a developing society: Perspectives from an African university. In: RAYNAL, JA (ed.) *Hydrology and Water Resources Education Training and Management*. Water Resources Publications, Littleton, Colorado. 478 pp.
- RODDA, JC (1992) Education and training in hydrology - Some problems from a WMO perspective. In: RAYNAL, JA (ed.) *Hydrology and Water Resources Education Training and Management*. Water Resources Publications, Littleton, Colorado. 478 pp.
- YEVJEVICH, V (1992) Education in water resources under continual evolution in their problems and in society's attitudes and demands. In: RAYNAL, JA (ed.) *Hydrology and Water Resources Education Training and Management*. Water Resources Publications, Littleton, Colorado. 478 pp.