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•The 23rd Annual Congress of the Limnological Society of Southern Africa

Modelling and monitoring water resources

from M.J. Silberbauer

The meeting was held in Windhoek in July, and was opened by J.H.J. Jordaan, the Secretary for Water Affairs in South West Africa/Namibia, who remarked that the country might at first seem a strange place to hold a conference on Limnology. After all, water is a very scarce commodity in Namibia, while limnologists are essentially aquatic beings. The truth is that in an arid climate where people must carry water long distances — whether on their heads in calabashes or via pipelines and canals — they are much more conscious of what a precious resource water is. In his welcome to the delegates, Mr Jordaan went on to describe his Department's functions in developing the country's water resources. A monitoring network keeps track of surface and underground water: there are 130 river gauging stations and several hundred stations monitoring underground water. The management, planning and development of the country's nearly 200 state water schemes have also included studies of the chemistry and biology of water supplies, and the assessment of the environmental impact of large water-supply schemes. Lately, too, a successful biological control programme to cope with the water-weed, *Salvinia,* has been carried out in the Caprivi Strip.

In his opening address, Dr P.M. Chutter (president of the Limnological Society) homed in on the problems of conflicting interests in the provision of water. He took as his example the Inanda Dam, which is being built on the lower Mgeni river in Natal. This dam is being constructed in the most exploited and densely populated catchment in Natal, where the population is expected to more than double by the end of the century. The dam will undoubtedly have a tremendous beneficial effect on the people of the region. Equally without doubt, Inanda Dam will have negative effects on the environment in which these people live. There will be eutrophication of the impoundment itself, because it will receive large amounts of sewage. There will be changes in the river hydrology and in the estuary. These may strike you as vague generalisations, coming from a scientist, but this is precisely the point that Dr Chutter was putting across. To the best of his knowledge, the experts in relevant fields (of which limnology is only one) had not been consulted nor had there been an environmental impact assessment. Construction will proceed and the effect on the river, the estuary and, ultimately, the people, will be determined empirically. In a continent of sometimes limited resources, it is important that development schemes be thought through from all angles by qualified people. An attempt to improve living conditions in one area must not result in disaster in another.

The conference proceedings were divided into five sections, representing the main areas of limnological research in Southern Africa. These were: Pans, Rivers, Wetlands, Impoundments and Ponds/Lakes. The first of these began with a report by D. Allan on the conservation status of Transvaal pans. He has catalogued well over eight thousand pans, in various states of repair. Some were fortunately enclosed in reserves, more by chance than by foresight, but many were intruded upon by various human developments such as fields, houses and rubbish dumps. Many would question the necessity for conserving pans, but from the discussion of this paper, and others concerning pans, it emerged that the plants and animals which live in them are not simply a few strays from the nearest permanent source of water. Processes of desiccation and rapid hydration occur in pans and these events ensure that the species of rotifers, crustaceans, insects and other pan-dwellers are adapted to a cycle of death by drought and resurrection by rain. These species assemblages and processes are unique, and support various other forms of life, such as waterfowl — which is surely sufficient reason for conserving their habitat.

The session on Rivers was dominated by papers on the Vaal river and the mountain streams of the western Cape. From the University of the Orange Free State came reports of heavy-metal concentrations in the sediments of the Vaal, algal species succession in the river water, and the problem of treating water from the Vaal Barrage, where there are very high concentrations of algal chlorophyll. The papers from the University of Cape Town covered process studies in mountain streams, the input of such materials as leaf litter into streams, blackwater chemistry and the threats posed by water diversion and abstraction. There was only one paper on the largest river in South Africa, the Orange. C. Benade, from the Cape Provincial Administration's Department of Nature and Environmental Conservation, is conducting a research programme on this vital resource in complete isolation. He made a plea for more attention to be paid to the Orange river system: it has already been substantially altered by the H.F. Verwoerd and P.K. le Roux dams, and receives a large input of pollutants from the Vaal. The Lesotho Highlands scheme will change the river still further. Perhaps the costs of such a study are intimidating in the present poor economic climate, but unless sufficient baseline information is collected, there will be no chance of conducting comparative surveys in the future. Monitoring and solving any problems which may develop will be extremely difficult.

E. Braune (South African Department of Water Affairs) provided some instructive estimates of the amount of money that sediment erosion and deposition cost South Africa each year. The principal costs were: loss of fertilizer by erosion (R34 million); loss of reservoir storage capacity by siltation (R32 million); losses resulting from soil erosion (R9 million); increased water purification costs (R7 million); dredging of estuaries (R2 million). It is still not commonplace to see the effects of environmental degradation expressed in cash terms, but it is important that these calculations be done. They are of much more use in persuading decision-makers than either emotional accusations or highly technical scientific reports.

Professor B.R. Davies (University of Cape Town) concluded the session with a plea for more research on the problems of South African rivers. Some programmes should be allowed to extend beyond the traditional three years, to obtain maximum benefit from the initial effort. He suggested also that river research should not be too rigidly classified into 'pure' and 'applied'. Much basic research is needed concerning the way rivers work and especially their ability to recover from the effects of pollution, diversion and impoundment.

Limnology meshes with a diversity of other disciplines, from geohydrology to marine biology. One area where limnology merges into terrestrial ecology is in the wetlands. Wetlands have not been too rigidly defined, but they include marshy areas, land where the soils are seasonally saturated, and vleis with dense stands of aquatic plants. They are sometimes important parts of river ecosystems and may trap silt, buffer the effect of floods and remove excess nutrients from eutrophic waters. Wetlands are also habitats for specialised plants and animals — often in need of preservation or conservation themselves.

Many wetlands are on private farms and are therefore potentially important agricultural land, whether for grazing or (after draining) for crops. Also, by definition, a wetland requires water: many reservoirs may have a detrimental effect by diverting water away from wetlands.

The scientists planning a national programme of wetlands research in South Africa envisaged drawing up an inventory of wetlands, stating where they are and what they are used for or useful for. Natal has made the most progress, but it has been a much more difficult task than expected. After two years' work they have only begun to scratch the surface. It is hoped that the developing technology of satellite remote sensing may prove a more rapid method of obtaining a broad overview than ground or aerial survey. Other research will be into wetland structure and function, application of existing legislation for their protection, and methods for informing the public of the value of wetlands. This last point is of immense importance, as about 90% of all wetlands are privately owned. An information leaflet has already been sent out to all farmers in Natal.

Impoundments provide almost the only freshwater lakes in Southern Africa. Their purposes are usually water storage and flood control, with recreation being a beneficial side-effect in some cases. Unfortunately, as with any large alteration of our environment, there has been a penalty to pay for these benefits. People doing research on rivers have found that the biological functioning of river systems is being impaired. The seasonal cycle of high and low flow is smoothed out and the annual discharge of water becomes much less than the natural rate. Apart from these concerns of the river scientists, there have been problems concerned with the inner workings of the impoundments themselves. Many have been trapped in a short-cut of the hydrological cycle. They receive heavy city pollution and must yield sparkling tap water — which very quickly re-enters them carrying a load of fertilizers, salts, heavy metals and diverse organic compounds. Much effort has been given to determining the fate of the nutrient elements phosphorus and nitrogen, which occur mainly as phosphate, nitrate, nitrite and ammonia. These promote excessive algal growth, and impoundments receiving water from developed catchments often resemble pea soup.

Two aids to monitoring and controlling impoundment eutrophication have been modelling and satellite remote sensing. The models developed in South Africa are conveniently grouped into 'complex' and 'simple'. Simple models are based on statistical analysis of a few important variables such as nutrient loading and rate of throughflow. The response of the system is measured in terms of some easily determined property, such as chlorophyll concentration. Complex models require much more data, and attempt to simulate the physical and biological processes occurring within a lake, not only the inflow and outflow of nutrients. There was some debate over the merits of these two methods for lake investigations, and it became clear that they are aimed at the solution of completely different problems. Simple models are most suited to helping impoundment or catchment managers make decisions on pollution standards and the running of dams. Complex models help researchers to understand the processes occurring in lakes, and to see the relationship between physical and biological conditions. Models have been extremely useful during the last decade as a goal for reservoir research and a test-bed for hypotheses. Now additional information on surface chlorophyll and the horizontal distribution of suspensoids has become available from satellite data. Modelling and satellite imagery are being combined to produce a new and more powerful analytical method.

In an overview of impoundment research in South Africa, Professor R. Hart (Rhodes University) suggested that it is now time to take stock of the vast store of data accumulated during the last ten years. Much of the current unifying theory is based on the simple, management models. Key physical, chemical and biological processes such as the release of sediment phosphorus, nitrogen cycling and primary production have been measured, but there are still many gaps. This is because research has been aimed at the solution of immediate eutrophication problems. The modelling of physical processes deserves more attention, because water temperature, light regime and circulation create the environment which moderates and limits biological processes.

There were only two papers on natural lakes, but they represented the largest possible range, from a small lava lakelet on Marion Island to the Great Lakes of Africa. Professor J.U. Grobbelaar reported on some of the work done by a team from the University of the Orange Free State, who spent two months on Marion Island in the South Atlantic. They did a short but very detailed study of the carbon cycle in a lava lakelet. They were able to construct a matrix model of the various carbon pools and their relationships, and concluded that about 44% of the carbon content of the lake was cycled within the system.

Dr G. Coulter (Rhodes University) gave an overview of the physical characteristics of the African Rift Valley lakes, and of the threats facing them. The African Great Lakes as a group are second only to the Great Lakes of North America in size. Lake Tanganyika, the deepest, is 650 km long, 1,5 km deep and covers an area of 33000 square kilometres. It holds 19000 cubic kilometres of water, many hundreds of times the volume of South Africa's total surface water reserves. Some idea of its age can be gained from the thickness of its sediments, which in some parts go down as much as 3 to 7 kilometres. This represents an age, at the present sedimentation rate, of 20 million years.

Lake Tanganyika and the other Rift Valley lakes, such as Victoria and Malawi, have been isolated for millions of years and several hundred unique species of fish have become established in each of them. Both the fish and the fresh water they live in represent an incalculable asset to Africa. The depth and volume of the lakes means that their water is replenished very slowly. It would take a thousand years for Lake

Tanganyika to fill up by natural inflow, compared with a year or two for most South African dams. This stability means that any pollutants which entered the lakes would remain there for several human lifespans. The dangers inherent in this are by no means fanciful, because industrial development is catching up with Africa. For example, an American company is prospecting for oil in Lake Tanganyika. Despite the North American experience of lake pollution, it appears that no environmental impact assessment is yet being planned.

Disturbances other than mineral exploration have already had an effect on the lakes. One example is the Nile perch problem. These fish were introduced into Lake Victoria in 1957 by a fisheries official, and have caused havoc ever since. They are voracious carnivores, and have completely changed the nature and efficiency of the fishery. There has been a shift from the more manageable and efficient sardines, low in the food chain, to large carnivores w-hich are much more difficult to catch and process.

These problems may seem remote to the South African limnologist, but we must remember that South Africa has the largest collection of indigenous expertise in African freshwater science. Clearly, any South African scientist wanting to set off on an expedition to East Africa to study some aspect of the Great Lakes will be confronted with certain political difficulties. Perhaps this will change in the lifetime of some of us, though things may get worse before they get better. Will the politicians w ho control some future Namibia welcome us in such a friendly fashion as our 1986 congress hosts welcomed us? Meanwhile, as Dr Coulter pointed out, there is a century's worth of existing reports on the Lakes, scattered around the globe. One does not need a visa to write a review paper.

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