Monitoring of water transfer from Katse Dam into the Upper Vaal river system: water utility's perspective

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Abstract Water quality is of prime importance to Rand Water's core business of ensuring a reliable supply of good quality drinking water to more than 10 million people. Rand Water has, therefore, implemented a water quality monitoring programme of the source water as well as the drinking water produced. The establishment of the Lesotho Highlands Water Transfer scheme necessitated the expansion of the monitoring programme. In 1996, Rand Water and Lesotho Highlands Development Authority (LHDA) signed an agreement to jointly develop an extensive water quality monitoring programme for the Lesotho Highlands Water Project (LHWP). Prior to this agreement, monitoring was mainly undertaken by consultants on behalf of LHDA in the main feeder rivers within the Katse Dam catchment (donor system). On the recipient system (Ash/Liebenbergsvlei), extensive physical and chemical monitoring was undertaken by Rand Water and Department of Water Affairs and Forestry (DWAF). Biological monitoring was however only carried out superficially prior to the release of water. Information gained from carrying out biological and chemical assessments clearly indicates that the water from LHWP has negatively impacted on the biological communities in the recipient system. The importance of detailed before and after biological and physio-chemical monitoring of both donor and recipient systems is emphasised.
Keywords Biomonitoring; interbasin transfer; water quality

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Introduction

In semi-arid regions, such as the greater part of Southern Africa, the transfer of water from areas of surplus supply to areas with water deficit has become a frequent solution to water scarcity. At present interbasin transfers (IBTs) account for the diversion of $1.6 \times 10^9 m^3$ per year and is projected to increase to 4.8×10^9 m^3 by the year 2017 (Cyrus *et al*., 1999). In most instances these transfer schemes were well assessed during the initial technical planning stages, but the potential ecological impacts were almost totally ignored. The information available does, however, show that any transfer of water within or between basins results in physical, chemical, hydrological and biological disturbances in both the donor and recipient systems, as well as their estuaries and local marine environments (Cyrus *et al*., 1999).

Rand Water is the largest water utility in South Africa and supplies bulk drinking water to local authorities, businesses and industries. More than 99% of the water abstracted and treated by Rand Water is surface water from the Vaal Dam, fed by the Vaal and Wilge rivers and supplemented by the Tugela-Vaal and Lesotho Highlands Water transfer schemes.

The LHWP is one of the most ambitious water schemes in the world, with the prime purpose of transferring water (70 m^3/s) from the upper portions of the Lesotho Highlands into the Vaal River basin. Water from this catchment is purified by Rand Water to supply drinking water to the economic heartland of South Africa. Water from LHWP was first released into the Vaal River basin in January 1998 and it was believed that erosion due to high velocities would cause water quality problems to the receiving waters. This particular study aims to investigate the general status of the invertebrate and fish communities in the Ash/Liebenbergsvlei system and attempt to relate it to the water quality of the water from the LHWP.

Methods

Historical data from baseline studies were compiled and assessed to give an indication of selected water quality variables (temperature, turbidity, electrical conductivity and pH). One site in the Katse Dam (Katse Dam Intake Tower) and three sites in the Ash and Liebenbergsvlei rivers were selected (Site AA, AB and WL). Site AA in the Ash River is upstream of the tunnel outfall; Site AB, also in the Ash River, is approximately eight kilometers downstream of the outfall and Site WL in the Liebenbergsvlei River is upstream of Vaal Dam (Figure 1).

The integrated Habitat Assessment System (IHAS) (Macmillan, 1997) was used to assess habitat availability for invertebrates. Aspects such as stream width, depth and velocity are included as a means of characterising the stream. Benthic macroinvertebrate communities were used to determine site-specific ecological integrity, using the South African Scoring System, version 4 (SASS4) (Thirion, 1995). Fish community studies were also undertaken. Sampling of fish was done by applying electro-narcosis, either by wading in shallow biotopes or by using a boat for deep biotopes.

Results and discussion

Due to governmental red tape and protocols, as well as different consultants undertaking the baseline studies, it was difficult to obtain data. Data are only available where joint monitoring by Rand Water, DWAF and LHDA was undertaken. Multinational projects of this nature or other large projects should implement mechanisms whereby data are readily available and accessible by external parties. Futhermore, lack of biological monitoring limits detailed assessment of the affected systems. This again stresses the importance of detailed planning of water quality monitoring programmes before and after the release of water both in the recipient and donor systems.

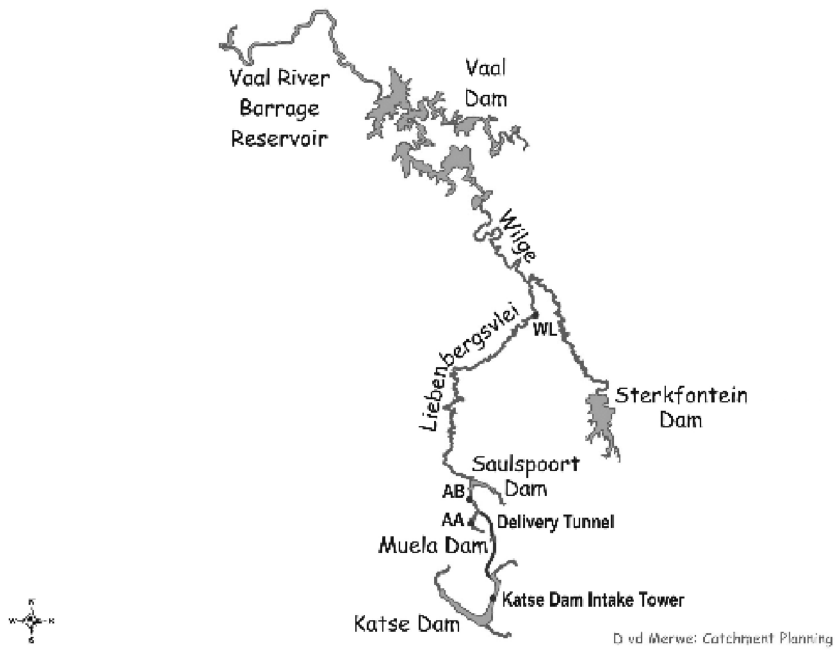

Figure 1 Map of the study area

Physical water quality parameters were measured *in situ* at each sampling site where SASS4 and fish biomonitoring were conducted. Surface water quality variables indicate differences between donor and recipient systems.

Low alkalinity was recorded in the Katse Dam Intake Tower during the entire monitoring period (Figure 2A) with the highest mean alkalinity value of 39 mg/l recorded during 1998. However, Site AA (upstream of the outfall) had the highest alkalinity mean value (360 mg/l) during 1999. No changes in alkalinity were observed at Site AB after the release of water from LHWP, as it remained low throughout the entire monitoring period and ranged between 38 mg/l and 40 mg/l. Site WL experienced a significant decrease in alkalinity following the release of water from LHWP in 1998. During 1998, the mean value for alkalinity decreased from 171 mg/l to 48 mg/l during 1999 at this site. This implies that the Ash/Liebenbergsvlei system naturally has high alkalinity, which is presently lower due to the LHWP water release. A similar pattern with regards to conductivity was observed (Figure 2B). No data were available for sites AA and AB prior to the release of the LHWP water. Higher mean temperatures were recorded at Katse Dam Intake Tower which ranged between 14°C and 20°C, compared to certain sections of the recipient system (e.g. Site AA) where the mean temperatures were as low as 10°C during 1999 (Figure 2C). High turbidities were observed from the sites AB and WL that are downstream of the Katse Dam outflow. This was especially evident at Site WL after the release of water in 1998 (Figure 2D). This can be attributed to the increased flow regime, which leads to scouring and erosion of riverbanks and beds.

Good IHAS scores were obtained at Site AA (85%) but poor IHAS scores were recorded at sites AB and WL, 46% and 43% respectively (Figure 3). Therefore, good invertebrate scores would be expected to occur at Site AA. Most of the potential biotopes have dimin-

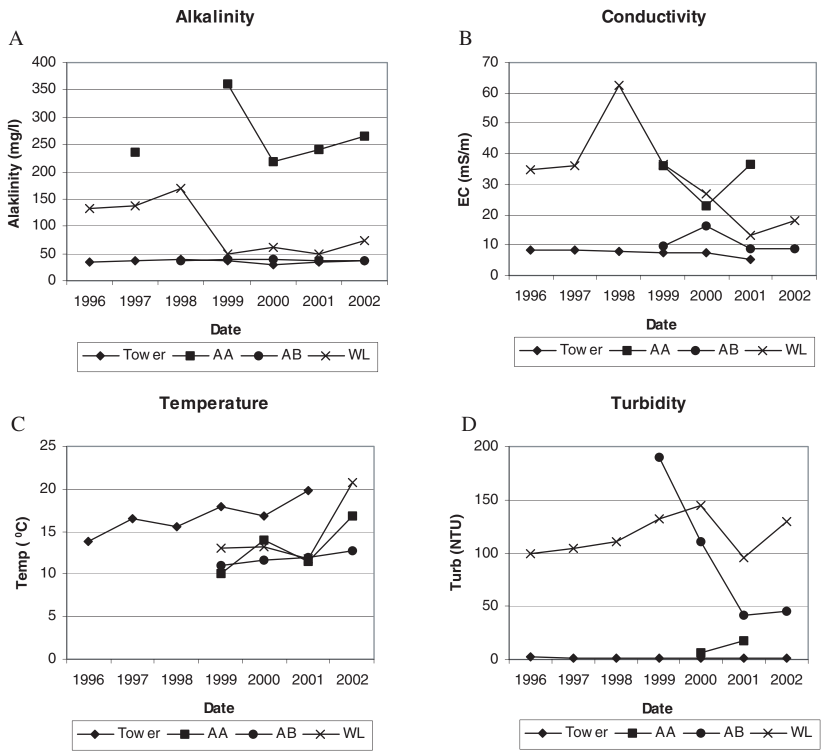

Figure 2 Physical water quality for selected sites in the study area

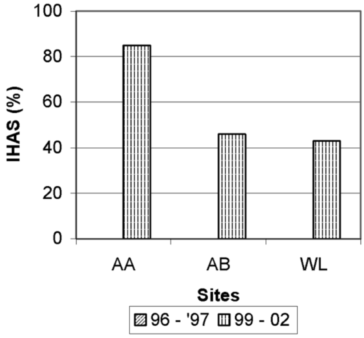

Figure 3 IHAS scores for selected monitoring sites in the Ash/Liebenbergsvlei system

ished as a direct consequence of erosion and deposition caused by the unnatural release of high velocity water from LHWP. IHAS, for all the sites, was not undertaken prior to the release of LHWP water.

Good invertebrate scores were observed at all the sites during 1996 to 1997 biomonitoring (Figure 4A). Deterioration in SASS4 scores was noted during 1999 to 2002 biomonitoring at the sites downstream of the Katse Dam outfall (sites AB and WL). Number of families score depicted the same trend as for SASS4 scores, whereby the deterioration in number of families at sites AB and WL downstream of the Katse Dam outfall experienced lower diversity than the period before the water transfer (Figure 4B). These sites were compared to Site AA, which was not affected by the release of the water from the LHWP, which confirmed deterioration in the invertebrate diversity only after the release of the water. This can primarily be attributed to the following.

- The increased flow, which tends to change plant growth patterns which in turn changes the distribution of invertebrates. The increased flow regime can also remove detritus material with the ultimate loss of food supply to detritivores.
- High amounts of suspended solids can affect the communities' structures by reducing light penetration because of increased turbidity. This also affects the photosynthetic rates of algae and submerged macrophytes thus affecting animals that depend on them for food, shelter and support.
- Increased deposition can change the riverbed so that burrowing organisms overwhelm other organisms that depend on stones for adherence.

Nine fish species (*Austroglanis sclateri, Barbus kimberleyensis, Barbus anoplus, Barbus aenus, Clarias gariespinus, Cyprinus carpio, Labeo umbratus, Labeobarbus*

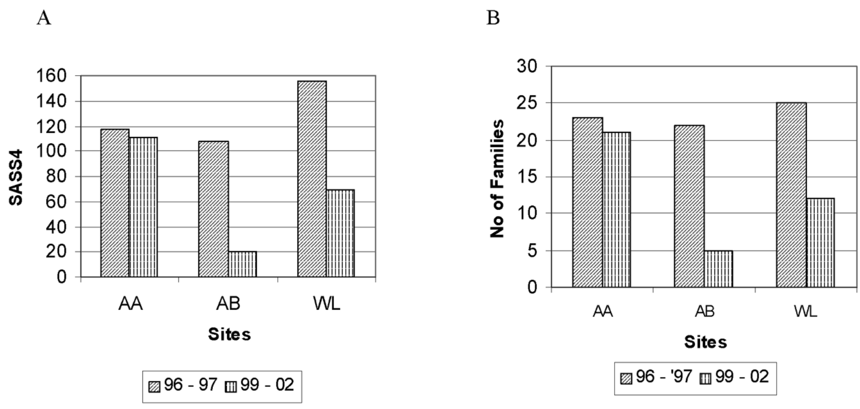

Figure 4 Macroinvertebrate scores for selected sites in the Ash/Liebenbergsvlei system

kimberleyensis and *Micropterus salmoides*) were recorded during the 1996 and 1997 biomonitoring. There were between one and seven species present at each site, out of the total number of nine species found. Only two specimens of the ubiquitous *C. gariepinus* were found. Prevalence of *L. kimberleyensis*, a fish that is apparently becoming scarcer throughout its area of occurrence, was evident. Site AA consisted only of minnows (*B. anoplus*) as this site is a shallow weak stream. At Site AB, a range of species was observed, indicating successful breeding.

Following the release of high volumes of water from LHWP in 1998, six fish species (*Austroglanis sclateri*, *Barbus anoplus, Clarias gariepinus, Cyprinus carpio, Labeobarbus aeneus* and *Labeo capensis*) were recorded during the period 1999 and 2002. Only two fish species (*L. aenus* and *B. anoplus*) were sampled at Site AB between 1999 and 2002. This indicates that some of the fish species that were present prior to the release of water could not tolerate conditions created by increased flow. Although rare, the presence of *A. sclateri* at Site WL following the transfer of water is encouraging because this species is sensitive to changes in the aquatic ecosystem and its conservation status is rare-indeterminate. This is an indication that this species is possibly adapting to conditions of increased flow.

Other potential negative impacts on the biota, associated with interbasin transfers, include the transfer of organisms such as phytoplankton, a potential food source for invertebrates, which facilitates dispersion of species, including unwanted invasive species, unwanted predators, fish diseases, parasites and their intermediate hosts. Fish pheromones can also be transferred which confuse migratory salmonids returning to spawn in natal streams. Death by asphyxiation of sensitive fish and invertebrates due to intermittent releases of stored water, possibly low in dissolved oxygen and high in sulphides, can occur when the transfer scheme is operated infrequently (Hellawell, 1986). There is also a possibility of reunion of once-isolated indigenous species. IBTs can act as unwitting experiments in genetics, the once-separated populations mixing and interbreeding, altering unique gene pools and preventing speciation (and thus decreasing biodiversity) (Davies and Day, 1998).

Conclusions

The information gained from this study shows the following.

- There is a need for detailed biological and physio-chemical water quality monitoring when large IBTs like the LHWP are undertaken.
- Mechanisms should also be put in place where data will be readily available for specific studies.
- The joint monitoring between Rand Water and LHDA is very successful and mutually beneficial to the two organisations as there is transfer of skills as well as sharing of costs. Data and information are also obtained on a routine basis for their strategic planning.
- Water quality deterioration was evident in the recipient system. Decrease in alkalinity and conductivity in the Ash/Liebenbergsvlei system after the transfer of water from LHWP is impacting negatively on the aquatic fauna.
- High velocity of water in the Ash/Liebenbergsvlei system has resulted in lowered invertebrate and fish diversity. This is because of change in habitat structure, loss of food supply and high turbidity, as well as temperature changes.

References

Chutter, F.M., Palmer, R.W., Seaman, M.T. and Du Preez, P.J. (1997). *A baseline study of the As/Liebenbergsvlei/Wilge River in relation to the changes expected to arise from the transfer of water from Lesotho*. Draft Report. DWAF 69 pp.

Cyrus, D.P., Wepener, V., MacKay, C.F., Cilliers, P.M., Weerts, S.P. and Viljoen, A. (1999). *The effects of Intrabasin Transfer on the Hydrochemistry, Benthic Invertebrates and Ichthyofauna of the Mhlathuze Estuary and Lake Nsezi*. Water Research Commission Report No. 722(1)99, 253 pp.

Davies, B. and Day, J. (1998). *Vanishing Waters*. University of Cape Town Press. University of Cape Town. P/B Rondebosch. Cape Town. South Africa.

Hellawell, J.M. (1986). *Biological Indicators of Freshwater Pollution and Environmental Management*. Elsevier Applied Science Publishers. London and New York. 449 pp.

MacMillan, P. (1997). *Integrated Habitat Assessment System. (IHAS) Version 2. Rapid Bioassessment of Rivers and Streams*. Report No ENV-P-I 98232 for Water Resources Management Programme, CSIR, Pretoria.

Thirion, C.A., Mocke, A and Woest, R. (1995). *Biological Monitoring of Streams and Rivers using SASS4: A User Manual*. Final Report, No. N 000/00/REQ/1195. Institute of Water Quality Studies, Department of Water Affairs and Forestry.