A Baseline Study of the Mokolo and Lephalala Rivers in the Waterberg Area

De Klerk, A.R* and De Klerk, L.P.

CSIR, Natural Resources and the Environment,

PO Box 395, Pretoria, 0001, South Africa; *Correspondence: adklerk@csir.co.za

INTRODUCTION

South Africa faces a growing water supply crisis caused by a combination of low rainfall, high evaporation rates, and a growing population. This situation is particularly true for the Limpopo River basin which is already water-stressed (Ashton *et al.*, 2008). The Waterberg hills form the headwaters of four main rivers in the Limpopo Water Management Area, namely the Lephalala, Mokolo, Matlabas and Mogalakwena rivers. The aquatic ecosystems that characterize the rivers draining the Waterberg and flowing to the Limpopo River are already modified and increasingly vulnerable to change (RHP, 2006).

Current plans to resolve South Africa's energy crisis and ensure the country's future power needs will bring dramatic changes to the Waterberg area, where a coalfield was discovered in the 1920s. Since 2004 the Department of Minerals and Energy has granted licenses to 532 coal prospectors in the area. Faced with the electricity crisis and apparently with enough coal in the Waterberg to supply South Africa's needs for the next 150 to 200 years, up to 11 new power stations, possibly 40 new coal mines and two new SASOL-type oil-from-coal operations will lead to dramatic changes in the region. All these new developments will be accompanied by a rapid growth in population and demands for water for domestic, irrigation, mining, industrial and recreational uses (Schachtschneider *et al.*, 2010). The objective of this study was to develop an accurate baseline estimate of the current ecological status and integrity of the aquatic ecosystems in the Mokolo and Lephalala rivers. This can serve as a defensible reference against which to assess the scale and significance of future impacts.

MATERIALS AND METHODS

Aquatic macroinvertebrates were sampled using a standard sweep net (300 mm x 300 mm with 1000 µm mesh), which was held immediately downstream of the area to be sampled. All the available biotopes at each site were sampled sequentially. The macroinvertebrates were then identified to the appropriate taxonomic level, according to Gerber and Gabriel (2002), and enumerated using a sub-sampling technique. An assessment of the various macroinvertebrate habitat availability and quality at each site was done using the Invertebrate Habitat Assessment System (IHAS) according to McMillan (1998).

Qualitative (or semi-quantitative) fish sampling was undertaken to determine the fish assemblages. Approximately 50 m of river, including the main habitat types (*e.g.*, riffles, runs, pools) were sampled at each site, using an electro-fishing unit. Sampling commenced downstream, moving further upstream, whilst sampling all wadeable habitats within the reach. Afterwards the collected fish were identified and released back into the river. The relative habitat availability for fish was determined through an adapted approach followed in the Fish Response Assessment Index (FRAI) (Kleynhans, 2008).

Univariate statistical analyses were applied in order to elucidate spatial changes in the community structures. It included Margalef's index (d), which is a measurement of the number of individuals present for a given number of species (Margalef, 1951), and Shannon diversity index (H'), which incorporates species richness and equitability components (Shannon, 1948).

RESULTS

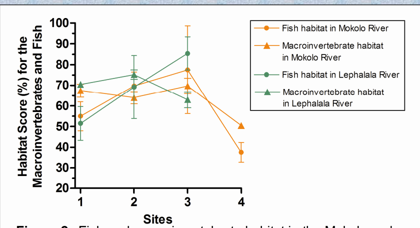

Figure 2: Fish and macroinvertebrate habitat in the Mokolo and Lephalala rivers.

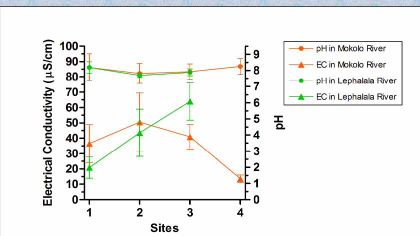

Figure 3: Electrical conductivity (EC) and pH in the Mokolo and Lephalala rivers.

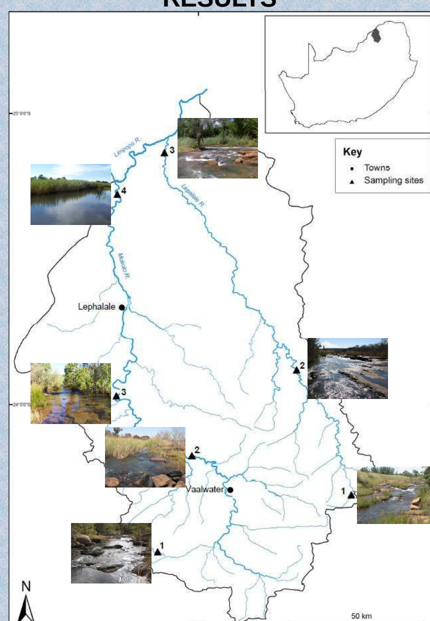

Figure 1: Map of the study area within the Limpopo Province, indicating the sampling sites.

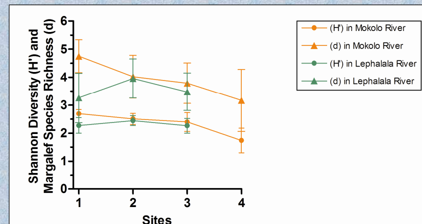

Figure 4: Shannon diversity and Margalef species richness values for macroinvertebrates sampled in the Mokolo and Lephalala rivers.

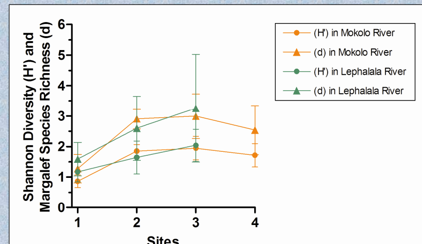

Figure 5: Shannon diversity and Margalef species richness values for fish sampled in the Mokolo and Lephalala rivers.

DISCUSSION

According to Lenat (1984), the number of macroinvertebrate taxa in an aquatic ecosystem is representative of the water quality of the specific system. If a system becomes more polluted, the intolerant species will start to disappear from the system, ultimately reducing the number of taxa present in the system. Throughout this study, consistently high numbers of different macroinvertebrate taxa were found in the Mokolo and Lephalala rivers. However, a decrease in diversity can be noted along a longitudinal gradient from the upper reaches of the Mokolo River to sites located further downstream. The changes in macroinvertebrate diversity and richness noted from Sites 1 to 3 in the Lephalala River correspond with the trend noticed in habitat availability at these sites. These changes in macroinvertebrate diversities in the two rivers may be due to changes in flow (*e.g.,* the lower Mokolo River being extensively mined for sand) and/or habitat availability (Figure 2), rather than water quality (Figure 3), which tends to be relatively good. This water quality status is also reflected by the presence of sensitive macroinvetebrate species (*e.g.,* Heptageniidae, Oligoneuridae and Perlidae) present in the Mokolo and Lephalala rivers (Gerber and Gabriel, 2002).

This study indicated that the fish assemblages in both the Mokolo and Lephalala rivers are in a relatively good condition. An increase in the fish diversity and species richness was observed from Site 1 to Site 3 in both the Mokolo and Lephalala rivers, whereafter it decreased slightly at Site 4 in the Mokolo River. These modifications may be attributed to changes in habitat, decreased overhanging vegetation and the presence of migration barriers (Kanehl and Lyons, 1992). Fish species such as *Chiloglanis pretoriae* and *Barbus eutenia* (and to a lesser extent *Aplocheilichthys johnstoni*, *Labeo molybdinus* and *Micralestes acutidens*) in the mainstem of both rivers give a good indication of the relatively good water quality found in these rivers. Species such as *Chiloglanis pretoriae* are also flow-sensitive and thus may be useful indicators of deteriorating water quality and flow conditions in these rivers (Schachtschneider *et al.*, 2010).

Thus, the changes to macroinvertebrate and fish diversity, as well as species richness, found in these two rivers appear to be attributable to modifications in flow and habitat as opposed to deterioration in water quality. The upper reaches of both the Mokolo and Lephalala rivers appear to be important with respect to maintaining the wild populations of an as yet unidentified fish species from the genus *Barbus*, which was only found in the upper tributaries of the Mokolo and Lephalala rivers.

CONCLUSIONS AND RECOMMENDATIONS

The data obtained during this study proved that the Mokolo and Lephalala rivers have relatively good water quality (confirmed through the presence of certain sensitive macroinvertebrate and fish species), with both the macroinvertebrate and fish populations appearing relatively intact. Decreased diversity and richness of these organisms appeared to be mainly attributable to modifications in flow and lower habitat availability.

Given the concerns about future deposition of atmospheric pollution from the proposed coal-fired power plants in the Waterberg area, the presence of sensitive macroinvertebrate and fish species in the mainstem of both these rivers may be useful indicators of deteriorating water quality and flow conditions in these rivers. Thus, these two rivers should be monitored regularly for early detection of deteriorations in water quality.

REFERENCES

Ashton, P.J., Hardwick, D. and Breen, C.M. (2008). *Changes in Water Availability and Demand within South Africa's Shared River Basins as Determinants of Regional Social and Ecological Resilience.* In: Burns, M. and Weaver, A. (Editors) *Exploring Sustainability Science: A South African Perspective*. Sun Media: Stellenbosch, South Africa. Pages 279-310.

Gerber, A. and Gabriel, M.J.M. (2002). *Aquatic Invertebrates of South African Rivers.* First Edition. Department of Water Affairs and Forestry: Pretoria, South Africa.

Kanehl, P. and Lyons, J. (1992). *Impacts of In-stream Sand and Gravel Mining on Stream Habitat and Fish Communities, Including a Survey on the Big Rib River, Marathon County, Wisconsin*. Research Report No. 155. Department of Natural Resources: Wisconsin, USA.

Kleynhans, C.J. (2008). *Fish Response Assessment Index (FRAI).* Module D: Volume 1. In: *River Ecoclassification: Manual for Ecostatus Determination* (Version 2). Joint DWAF and WRC Report No. TT 330/08. Water Research Commission and Department of Water Affairs and Forestry: Pretoria, South Africa.

Lenat, D.R. (1984). Agriculture and stream water quality: A biological evaluation of erosion control practices. *Environmental Management,* **8**: 333-344.

Margalef, R. (1951). Diversidad de especies en las comunidades naturales. *Publicaciones del Instituto de Biologia Aplicada de Barcelona,* **6**: 59-72.

McMillan, P.H. (1998). *An Integrated Habitat Assessment System (IHAS v2), for the Rapid Biological Assessment of Rivers and Streams.* A CSIR research project. Report No. ENV-P-I 98132 for the Water Resources Management Programme, CSIR: Pretoria, South Africa.

River Health Programme (2006). *State-of-Rivers Report: The Mokolo River System.* Department of Environmental Affairs and Tourism: Pretoria, South Africa.

Schachtschneider, K., Ashton, P.J., Dabrowski, J.M., De Klerk, A.R., De Klerk, L.P., Hall, G., Kleynhans, C.J., MacMillan, P., Oberholster, P.J. and Woodbourne, S. (2010). *Waterberg Project: Final 3 Year Report*. CSIR-NRE Internal Report, 21 January 2011. Report No. CSIR/NRE/WR/IR/2011/0046/A. xiii + 113 pages. CSIR: Pretoria, South Africa.

Shannon, C.E. (1948). A mathematical theory of communication. *The Bell System Technical Journal,* **27**: 379–423, 623–656.

ACKNOWLEDGEMENTS

The authors would like to thank Dr CJ Kleynhans and Dr PJ Ashton for accompanying the sampling team on field visits. Their extensive knowledge of the Waterberg Rivers and their associated fauna and abiotic processes has been invaluable at all stages of this project.