SHORT, NON-REFEREED PAPER

RIVER WATER QUALITY IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

The sustainable cultivation of crops under irrigation requires water of a suitable quality, most especially with regards to salinity and sodicity. Agriculture can impact water quality negatively, mainly through the export of salt, nitrogen (N) and phosphorus (P) from the root zone to waterways. In this study, long-term chemical water quality data obtained from the South African Department of Water Affairs was used to assess the quality of river water in the Crocodile, Komati-Lomati and Pongola River Catchments and for the Mkuze and Umfolosi Rivers. Electrical conductivity (EC) data shows an increase in salt concentration as the rivers run their course as a result of various anthropogenic activities in the catchments. Irrigators located further downstream will therefore generally have to pay better attention to salinity management. A fair to marginal sodicity hazard is present for the Pongola River, and a more serious salinity and sodicity hazard is present for the Mkuze and Umfolosi Rivers. Irrigators in these regions are therefore encouraged to monitor water quality and adapt management practices accordingly. Nutrient enrichment was generally evident for all the rivers. More intensive monitoring, including organic forms of N and P, is recommended to improve our understanding of the contribution of different anthropogenic activities to river water pollutant loads.

Keywords: irrigation, surface water quality, salinity, sodicity, nitrogen, phosphorus

Introduction

In South Africa, irrigated sugarcane production is almost exclusively practiced north of the Tugela River (29°12'S, 31°29'E). Sustainable irrigation is dependent on water of appropriate quality, especially with regards to salinity and sodicity. Irrigated agriculture often impacts negatively on water quality through increasing salt and nutrient loads to waterways via irrigation return flows. In the Malelane and Komati regions, the major sources of irrigation water are the Crocodile, Lomati and Komati Rivers and some of their tributaries, while the source of irrigation water in the Pongola region is water from the

Pongola and Bivane Rivers. Further south, significant extractions of water for irrigation are made from the Mkuze and Umfolosi Rivers. Increased anthropogenic activities and utilisation of limited water resources in South African catchments has led to concerns about deterioration in water quality. In this paper, the current status and some long-term trends in chemical water quality are analysed for the major rivers in the South African sugar industry.

Materials and Methods

Chemical water quality data was obtained from the South African Department of Water Affairs for the period 1999-2009. Electrical conductivity (EC), sodium adsorption ratio (SAR), pH, inorganic nitrogen (N), nitrate and nitrite (NO_3+NO_2) and phosphate-phosphorus (PO_4-P) measurements were considered. Data from the following sampling points were used:

- Crocodile River: Karino (25°28’S, 31°06’E), Thankerton (Point 2: 25°26’S, 31°38’E) and Tenbosch (25°21’S, 31°57’E) (listed upstream → downstream)
- Lomati River: Lomati (25°40’S, 31°34’E)
- Komati River: Komatipoort (25°26’S, 31°57’E)
- Bivane River: Welgelegen (27°31’S, 30°51’E)
- Pongola River: Mhlati (27°21’S, 31°46’E)
- Mkuze River: Morrisvale (27°66’S, 32°42’E)
- Umfolosi River: Monzi (28°46’S, 32°32’E).

As the Lomati River converges with the Komati River, and the Bivane River converges with the Pongola River, the Lomati and Komatipoort and Welgelegen and Mhlati sampling points can be considered to be in series, and comparison of measurements for these points provides additional spatial information on water quality.

Results

River water is generally of good quality in the South African sugar industry with regards to salinity, but higher salinity levels are observed for the Crocodile River at Tenbosch, for the Komati, Pongola and Umfolosi Rivers and most notably for the Mkuze River (Table 1). Electrical conductivity data for the Crocodile River shows that salt concentrations increase as the river run its course (Figure 1). This can also be clearly observed for the Komati-Lomati and Pongola River Catchments. There is significant variability in river water EC with time at the sampling points, and over the longer term, there are clear trends of an increase in EC in all cases except for the Pongola River Catchment (data not shown).

Hazards due to sodicity exist for the Pongola and Mkuze Rivers and to a slightly lesser extent for the Umfolosi and Komati Rivers (Table 1). Similar to EC, SAR increases as the Crocodile River runs its course and this can also be observed for the Komati-Lomati and Pongola River Catchments. For the Crocodile River, no change in SAR since pre-1993 levels has been observed at Karino, but interestingly, mean SAR at Tenbosch has decreased from 2.0 for the 1983-1993 period (Meyer and van Antwerpen, 1995) to 1.3 in this study. In contrast, SAR levels for the Komati River have increased from levels measured during a study conducted during the 1972-74 period (Johnston, 1976).

Table 1. Water quality data for key rivers in the South African sugar industry for the period 1999-2009.

River	Sampling point	EC	SAR	pH	Inorg N	NO_3+NO_2	PO_4-P
		mS/m			mg/L		
Crocodile	Karino	23	0.5	7.8	0.62	0.55	0.055#
	Thankerton	38	1.0	8.1	0.58	0.54	0.042#
	Tenbosch	48*	1.3	8.2	0.44	0.39	0.032
Lomati	Lomati	18	0.7	7.8	0.48	0.36	0.024
Komati	Komatipoort	56*	1.5*	8.3	0.44	0.39	0.031
Bivane	Welgelegen	11	0.4	7.7	0.31	0.27	0.032
Pongola	Mhlati	57*	2.5*	8.4	0.65	0.62	0.035#
Mkuze	Morrisvale	80*	2.6*	8.0	0.23	0.15	0.033
Umfolosi	Monzi	66*	1.9*	8.2	0.24	0.17	0.042#

*Classified only as fair for irrigation purposes (EC ≥ 40 mS/m, SAR ≥ 1.5; Koegelenberg, 2004)
#Classified as eutrophic (≥ 0.035 mg P/L; OECD 1982)

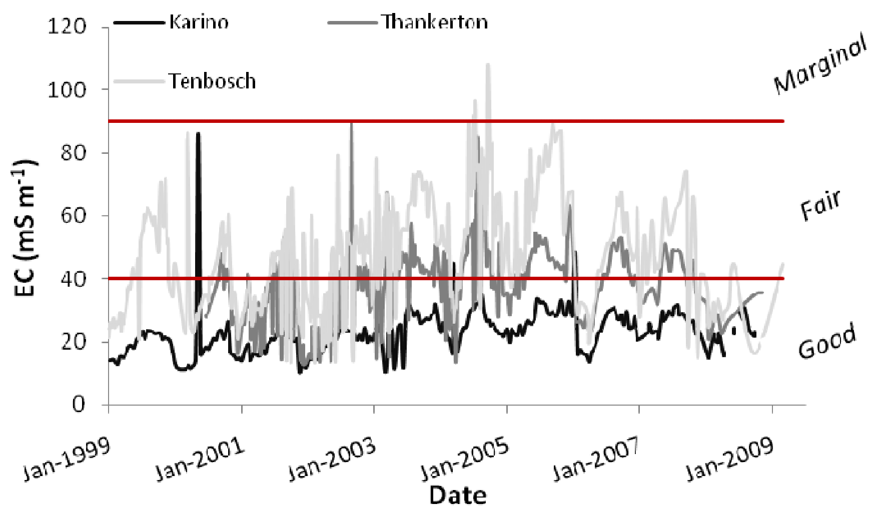

Figure 1. **Crocodile River electrical conductivity (EC) measured at Karino, Thankerton and Tenbosch for the period 1999-2009 (red horizontal lines separate different salinity categories, classified as good, fair and marginal).**

Mean pH was observed to range from 7.8 to 8.4 for the rivers assessed. As there are intensive mining operations taking place in the Crocodile and Komati-Lomati River Catchments, it appears that the potential for acid mine drainage to lower river water pH is being countered by the addition of salts to the system from irrigation return-flow which results in increased pH levels.

Evidence of nutrient enrichment in the rivers analysed is widely apparent. Phosphate-phosphorus concentrations are at eutrophic levels for the Crocodile River at Karino and Thankerton and for the Umfolosi River. In contrast to EC and SAR, measured inorganic N and PO_4-P concentrations were most often lower at Tenbosch than at Karino, with Thankerton having intermediate concentrations.

Discussion

Potential salinity and sodicity problems for irrigated soils in the regions discussed in this paper indicate that it is essential for farmers to monitor the quality of their irrigation water and soil, and apply mitigation management practices where necessary. The reason for higher nutrient enrichment upstream than downstream for the Crocodile River is not clear, but may be a result of in-stream processes such as carbon metabolism, sedimentation, bacteria mediated species transformation and denitrification – all of which can cause variations in nutrient forms during the transport process (Downing, 1997; Behrendt and Opitz, 1999; Brodie and Mitchell, 2005). The analysis of organic N and P forms, in addition to inorganic forms, is required to improve our understanding of this phenomenon and is recommended. The impacts of acid mine drainage and high-salt containing irrigation return flows on river water pH also needs further investigation. Finally, it is recommended that chemical water quality and flow measurements be made at the same location to best facilitate the determination of pollutant loads.

Conclusions

The quality of water used for irrigation in the northern sugarcane producing regions of South Africa is generally good, with some salinity and sodicity hazards in certain areas. River water quality data obtained from the South African Department of Water Affairs is extremely useful to assess irrigation water quality and to monitor long-term trends, as shown in this study. Further enhancements and intensification of the monitoring that is currently taking place will lead to better quality and more detailed temporal and spatial water quality data to improve decision making. It is recommended that more detailed water quality studies be undertaken to improve the sustainability of irrigation of sugarcane and other crops in these regions.

Acknowledgements

The authors thank the Department of Water Affairs for access to their data for this study.

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