



## Impact on water quality of land uses along Thamalakane-Boteti River: An outlet of the Okavango Delta

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### ABSTRACT

Botswana is a semiarid country and yet has one of the world's famous wetlands: the Okavango Delta. The Thamalakane-Boteti River is one of the Delta's outlets. The water quality of the Thamalakane-Boteti River was determined and related to its utilisation. The major land uses along the Thamalakane River within Maun are residential areas, lodges, hotels, and grazing by cattle and donkeys. The water is used as a source of water for livestock, wildlife in a game park, horticulture and domestic applications including drinking. The river is also used for fishing.

To check whether these activities negatively impact on the water quality, pH, electrical conductivity, dissolved oxygen, temperature, total dissolved nitrogen and phosphorus, *Faecal coliforms* and *Faecal streptococci* and selected metals were determined from July 2005 to January 2006. The pH was near neutral except for the southern most sampling sites where values of up to 10.3 were determined. Dissolved oxygen varied from 2 mg/l to 8 mg/l. Sodium (range 0.6–3.2 mg/l), K (0.3–3.6 mg/l), Fe (1.6–6.9 mg/l) conductivity (56–430  $\mu$ S/cm) and Mg (0.2–6.7 mg/l) increased with increased distance from the Delta, whereas lead showed a slight decline. Total dissolved phosphorus was low (up to 0.02 mg/l) whereas total dissolved nitrogen was in the range 0.08–1.5 mg/l. *Faecal coliform* (range 0–48 CFU/100 ml) and *Faecal streptococci* (40–260 CFU/100 ml) were low for open waters with multiple uses. The results indicate that there is possibility of pollution with organic matter and nitrogen. It is recommended that more monitoring of water quality needs to be done and the sources of pollution identified.

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### 1. Introduction

Integrated water resources management (IWRM) requires consideration of both the quantity and quality of water. Human activities have the potential to impair water quality and thereby reduce the utility of water as a resource, and degrading aquatic ecosystems. Impairment of water quality adversely affects attainment of socio-economic sustainability. A study carried out by Nhapi et al. (2002) established that due to water pollution, costs of water treatment had increased for Harare, Zimbabwe, and the costs of financing of water and wastewater treatment per household had increased beyond acceptable levels. Coordination of planning and management of land and water is one of the IWRM objectives formulated after realising that land uses affect both the quantity and quality of water. There is however inadequate understanding and ability to predict how human activities in different physiographic settings affect water quality especially in southern Africa. Studies aiming at improving our understanding of the linkages between

human activities and water quality such as mining (Ravengai et al., 2004, 2005; Ntengwe and Maseka, 2006; Lupankwa et al., 2006; Meck et al., 2006) urbanization and settlements (Mapani, 2005; Mwiganga and Kansiime; 2005; Nsubuga et al., 2004; Zingoni et al., 2005; Alemaw et al., 2004) irrigation and other land use (Basima et al., 2006; Mhlanga et al., 2006; Ngoye and Machiwa; 2004; Dzwauro et al., 2006; Ntengwe 2006) are important since outputs of such studies form the basis of designing measures for controlling water contamination, and water quality monitoring programmes.

The ability of wetlands to modify water quality is increasingly being appreciated (Nichols, 1983; Kadlec and Knight, 1996; Mugisha et al., 2007; Verhoeven et al., 2006). The Okavango Delta is one of the major freshwater wetlands of the world, within which evapotranspiration and chemical precipitation results in improvement of surface water quality of water (McCarthy 2006). Surface water within most parts of the delta is in the pH range 6.1–7.5, with acidic water occurring due to decomposition of aquatic plants (Ashton et al., 2003). Ashton et al. (2003) also found the electrical conductivity (EC) to be general low, 33–75  $\mu$ S/cm, and an indication of low total dissolved solids. Other water quality parameters revealed that water within the delta had no significant contamination. The Okavango Delta is largely a wildlife management area

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with controlled development of tourism facilities. What is however not known are the effects on water quality of human activities occurring immediately downstream of the delta along some of the rivers draining from it. Agricultural, industrial and urban activities such as those occurring within and around Maun, an urban village located along one of the outlets from the delta, have elsewhere been shown to adversely affect water quality (Nhapi et al., 2002; Ouyanga et al., 2006). Van der Post (2004) highlighted the potential for solid and liquid waste emanating from Maun polluting Thamalakane River which passes through this settlement. High concentrations of toxic chemicals and nutrients can lead to diverse problems such as toxic algal blooms, loss of oxygen, fish kills, loss of biodiversity, and loss of aquatic plant beds and coral reefs (Voutsas et al., 2001). Several studies elsewhere have investigated effects of human activities on water quality (e.g. Irmer et al., 1995; Arambarri et al., 1996; Fisher et al., 2000; Tong and Chen, 2002; Cheung et al., 2003; Barros et al. 1995; Xue et al., 2003; Simonova et al., 2003).

This study was conducted to determine effects of human activities within and around an urban village, Maun, on water quality of the Thamalakane–Boteti River which drains from the Okavango Delta. Information derived from this study can be used to determine if the water quality of the Thamalakane–Boteti River is being impacted upon by activities being carried out around it, recommend water quality parameters to be monitored and measures for controlling water contamination that may have been detected.

## 2. Materials and methods

### 2.1. Study area

The study was conducted along the Thamalakane and Boteti Rivers which for about 20 km passes through Maun Village in north-western Botswana (Fig. 1). This river bifurcates downstream of

Maun to form the Nhabe River which drains into Lake Ngami on the south-west, and Boteti River draining into Makadikgadi Pan to the south-east. The combined Thamalakane River and Boteti River is referred to as the Thamalakane–Boteti River. The river, is located in an almost flat area with Kalahari sands. Its gradient is about 0.006%. The Thamalakane–Boteti River has a channel width of 20–60 m within a 120 to 500 m wide valley. Flows in the Thamalakane–Boteti River comprise mostly of outflows from the Okavango Delta (Gieske, 1997; Wolski and Savenije, 2006; Mazvimavi and Motshalapheko, *in press*). A distinctive characteristic of this river is that it floods during the dry season, June to September. The average peak flow during May to August is  $7.2\text{--}8.1\text{ m}^3\text{ s}^{-1}$ , and  $1.2\text{ to }2.0\text{ m}^3\text{ s}^{-1}$  during the December to February low flow period. There are times when the river runs dry mostly from January to June during dry years. Due to the low gradient along the Thamalakane River, flows have very low velocities and the flood flows can take up to 14 days to flow over 9 km along a previously dry channel. The average annual rainfall occurs during the November to March period and is about 450 mm/yr, while the A-pan evaporation is 2010 mm/yr. Maximum monthly temperatures range from  $22^\circ\text{C}$  to  $34^\circ\text{C}$  while the maximum daily temperatures are in the order of  $30^\circ\text{C}$  to  $32^\circ\text{C}$  (Scudder et al., 1993).

Maun is a rapidly growing urban village which had a population of 4591 in 1964 and 49,822 in 2001 (CSO, 2003; van der Post, 2004). This village serves as the administrative centre for the North-West District Council, a major commercial centre, and the gate-way for tourists visiting the Okavango Delta. Commercial activities are mostly aimed at supporting government departments, district headquarters, and the thriving tourism industry with about 50,000–60,000 visitors passing through Maun every year (Mbaiwa, 2003; Magole and Gojamang, 2005). Land uses along the Thamalakane River in Maun comprise flood recession cultivation, vegetable gardens, lodges, hotels, and low and high income residential areas. These land uses have the potential to affect water quality

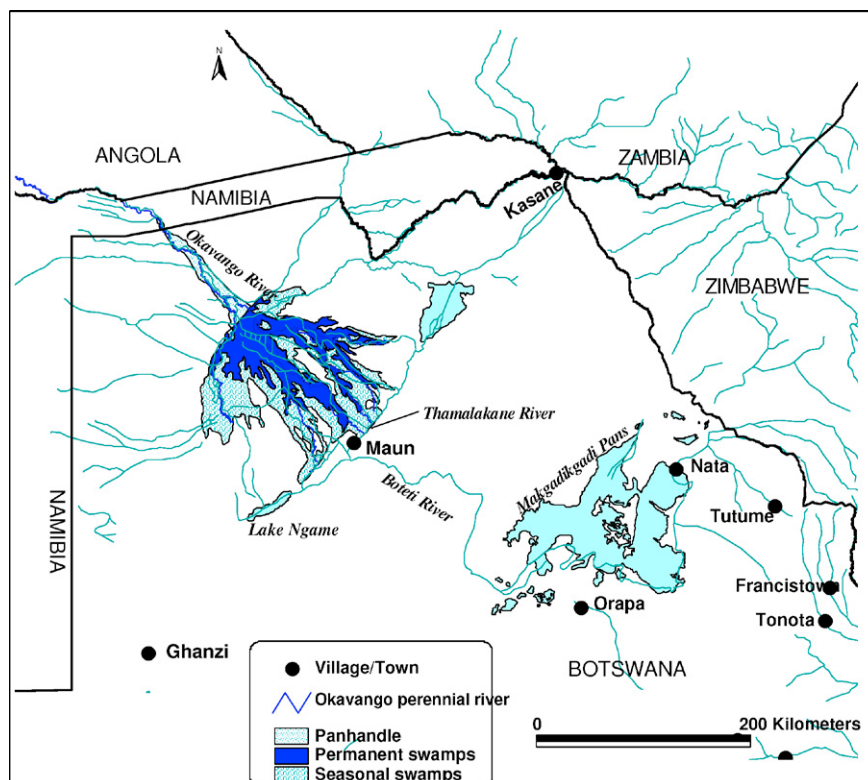


Fig. 1. Location of the Maun at the distal end of the Okavango Delta, and along Thamalakane River which later becomes Boteti River that drains into the Makgadikgadi Pans.

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