

Assessment and Evaluation of Surface Water Quality and Human Health Risk in the Inkomati River Catchment Basin, South Africa

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Abstract. Multivariate statistical methods, dimensionality reduction, clustering techniques, water quality indices (WQIs) of the Canadian Council of Ministers of the Environment (CCME), comprehensive pollution index (CPI), and human health risk assessment indices for carcinogenic risk of heavy metals, using the hazard index (HI), are utilized in this work to assess the surface water quality of the Inkomati catchment. Six physicochemical parameters – EC, pH, SO₄, Fe, Mn, and Cu were measured monthly from January 2015 to June 2019 from two sites Crocodile and Sabie rivers. The outcomes were compared to standard regulatory guidelines values. Recommended parameter values from US-EPA and peer-reviewed literature were used for the HI. The findings indicated that the river water was turbid and suffered from EC, specifically distressed due to trace metals. The US-WQI range (103.15-431.38) showed that the water quality level of the catchment was in the poor category but excellent during the winter. Water quality improved from marginal to good, according to the CCME-WQI scores, whereas the CPI scores (2.359-8.459) showed that the catchment's water quality was in a very poor condition. The US-WQI suggested that the overall quality of the basin has declined in both the upper and lower portions. The hazard quotient through ingestion exposure did not exceed the threshold limit of 1 for children. This implies there is no potential carcinogenic health risk from trace elements via ingestion of drinking water for children. However, cancer risk for children was computed in relation to Cu, Fe, Mn, and levels. It did not exceed the carcinogenic threshold limit of 10^{-4} for both sites.

AMS subject classifications: 9008, 9010, 9011, 65K05

Key words: Inkomati catchment, river water quality, water quality indices, robust statistical techniques, health risk assessment.

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1 Introduction

The availability of clean water is essential for nature as well as for people. The world's aquatic ecosystems are under tremendous stress because of large-scale urbanization, industrial and agricultural expansion, and rising water demand [56]. Population increases and their effects on the economy have threatened the availability of clean water in many parts of the world [69]. Changes in water quantity and quality threaten the availability of clean water. About 25 million people die from water contamination each year. In many nations, such as South Africa, industrial and residential human activity-related water contamination is a severe issue [25]. The growing pollution affecting water resources is due to anthropogenic activities such as industry, urbanization, afforestation, mining, agriculture, and unintentional water contamination (Khatri and Tyagi [36]). Anthropogenic activity has drastically decreased the surface water quality in catchments that support the aquatic ecosystem (Akhtar *et al.* [1]). Watershed water resources are essential to absorb or move runoff from agricultural land, as well as urban and industrial waste. According to Malaj *et al.* [43] and Anh *et al.* [4], river inflows considerably contaminate the water supply of a catchment, increasing the risk of severe ecological and sanitary issues. As towns and companies grew with collected rubbish in populous regions in the first half of the 19th century, environmental pollution issues in South Africa became apparent [16]. The biodiversity of water resources is currently in danger due to human-caused river pollution. It is possible to directly or indirectly alter the physical, chemical, or biological properties of a water resource to reduce its suitability for the intended use (National Water Act 36 of 1998 [62]). Rahman [51] stated that water is considered polluted if it has been affected by contaminants and is either unusable for human needs, such as drinking water, or has significantly lost the ability to support its constituent biotic communities, such as fish and macroinvertebrates. In terms of the National Water Act, the Department of Water Affairs and Forestry (DWAF) had to grant permission for any operations that could contaminate or degrade water resources to ensure proper management of the river. Even though a water usage license includes a requirement for water quality monitoring, rivers like the Crocodile River and Sabie River are still worsening. Though licensed, these activities could contaminate the river through seepage and the release of wastewater. The study area is situated in the Inkomati basin in South Africa, which was the subject of concern due to pollution from mining activities and agricultural sources (Jarmain [30]). The Inkomati basin in South Africa is primarily located within the Mpumalanga province, which has a semi-urban population. It comprises most of the water management area. The Mahala, Mapulanneng, Nsikazi, Nkomati, and Mswati regions are home to numerous rural communities. Some of the main metropolitan areas in the water management area are Nelspruit, White River, Komatipoort, Carolina, Badplaas, Barberton, Sabie, Bushbuckridge, Kanyamazane, and Matsulu. An area of 50,000 km² (19,000 sq mi) is thought to exist in the river basin. Despite the substantial amount of water used for diverse purposes, the river continues to experience problems directly related to water scarcity, leading to a decline in water quality, saltwater intrusion,