Development and application of a mathematical model for simulating the fate and transport of nutrient pollutants along the Msunduzi River

Kumarasamy Muthukrishna[1,2], Adu Joy[1], Demlie Molla[3,4]

[1]Civil Engineering Programme, School of Engineering, University of KwaZulu-Natal, Durban, 4000, South Africa

[2]Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai, 600072, India

[3]Department of Geological Science, University of KwaZulu-Natal, Durban 4041, South Africa

[4]School of Earth Sciences, Bahir Dar University, Bahir Dar P.O. Box 79, Ethiopia

kumarasamy@ukzn.ac.za

Streams are an important part of the ecosystem, which supports aquatic organisms and human water demand, and they need to be protected from all sources of pollution. Due to industrialization and a continuously growing population, water pollution has increased considerably in recent times. Many rivers in South Africa, including the Msunduzi River, are under threat because of an influx of nutrient pollutants. Eutrophication has been a crucial public health concern which has a dramatic impact on the aquatic ecosystem. Thus, the water quality deterioration calls for regular monitoring of the surface water so that the health of the aquatic ecosystems would be maintained. As water quality monitoring is time-consuming and labour-intensive, water quality models are significant tools for simulating water quality parameters and controlling the surface water pollution. This research presents the development of a proposed water quality model namely a Hybrid Cells-in-Series Model, to simulate the fate and transport of nutrient pollutants along Msunduzi River. These nutrient concentrations at different points along the river system were modelled by considering various processes such as the transformation of ammonia to nitrite, uptake of ammonia by the algae, respiration rate of the algae, benthic source input to the ammonia concentration, Nitrite to nitrate nitrification process, uptake of nitrate by algae for its growth and conversion of nitrate to nitrogen gas due to denitrification process in the water column. Then the model results are compared with the advection-dispersion equation model and with field data that shows a good agreement. Consequently, the model has demonstrated its capability of simulating ammonia nutrient pollution in rivers during non-monsoon periods and thus is a suitable tool for decision-making relating to water quality problems. Therefore, the simplicity of solving the HCIS model and its application to a natural stream makes it advantageous over other existing water quality models.