

Sewage discharges and nutrient levels in Marimba River, Zimbabwe

I Nhapi^{1*} and S Tirivarombo²

¹ Department of Civil Engineering, University of Zimbabwe, Box MP167, Mt Pleasant, Harare, Zimbabwe,

² Department of Environmental Science and Technology, Chinhoyi University of Technology, Private Bag 7724, Chinhoyi, Zimbabwe

Abstract

Population distribution, land-use, industrial activity, urban agricultural activities, and pollution control strategies in Harare, Zimbabwe, have all changed significantly since independence in 1980. The effects of these changes on water quality and the consequences on human and ecological health are of major economic and social importance. This study looked at pollution in the Marimba River, one of the major inflow rivers into the Lake Chivero, Harare city's main water supply source. The river was characterised using standard physical and chemical methods to assess water quality from June 2000 to December 2001. Monthly sampling results indicated high pollution levels, especially nutrients. Nitrogen values averaged $13.5 \pm 2.0 \text{ mg}\cdot\text{L}^{-1}$ as N, and phosphorus $2.6 \pm 0.6 \text{ mg}\cdot\text{L}^{-1}$ as P at the river's discharge point into Lake Chivero. The high nutrient values, exceeding acceptable limits, are indicative of industrial, agricultural, and sewage discharges upstream. The gross river pollution levels are detrimental to the downstream Lake Chivero. It was concluded that although there are other significant incidental sources of nutrient pollution in Marimba River, sewage effluent is by far the major polluter. It was established that pond overflow from Crowborough Sewage Treatment Works is the major source of sewage inflows and treating this to tertiary standard would result in 46% and 35% reductions respectively for total nitrogen and total phosphorus loads in the Marimba River.

Keywords: mass balance, nutrients, pollution, pasture irrigation, sewage treatment, water quality

Introduction

Nutrient enrichment is a major threat to freshwater ecology, leading to severe pollution problems. The disposal of untreated or partially treated wastewater into rivers is quite common in developing countries. This involves the discharge of nitrogen and phosphorus; the major nutrients that control biomass growth (Welch and Lindell, 1980) and these are available in abundance in municipal wastewater. In Zimbabwe, eutrophication-related problems have been reported in Lake Chivero (Moyo, 1997). The lake is located 35 km downstream of the capital city of Harare and supplies approximately 70% of the potable water needs in the area. Studies by JICA (1996) and Moyo and Worster (1997) suggest that the eutrophication of Lake Chivero is due to inappropriate sewage discharges. Earlier reports by Thornton and Nduku (1981) and McKendrick (1982) also point to a relationship between sewage discharges and water quality deterioration. Soluble nutrient concentrations have often been higher than permissible levels for drinking water in lakes of $0.3 \text{ mg}\cdot\text{L}^{-1}$ Total Nitrogen (TN) and $0.01 \text{ mg}\cdot\text{L}^{-1}$ Total Phosphorus (TP) (JICA, 1996).

The Mukuvisi and Marimba Rivers drain the City of Harare and discharge into Lake Chivero. A lot of interest has been generated on pollution in the Marimba River subcatchment. The impact of effluent discharges from the Workington Industrial Area and those of treated and partially treated sewage from Crowborough Sewage Treatment Works (CSTW) on the quality of the Marimba River was studied by Mathuthu et al. (1997). The levels of virtually all the water quality parameters monitored went up downstream of the sewage discharge point. Levels of phosphates exceeded maximum allowable WHO limits of $0.5 \text{ mg}\cdot\text{L}^{-1}$ and nitrates remained within

acceptable limits for effluent water. In a related study, Manjonjo (1999) also found that sewage effluent and irrigation seepage and runoff were impacting significantly on nutrient and heavy metal levels in the Marimba River.

The deterioration of water quality in the major inflow rivers into Lake Chivero greatly affects water treatment, rendering it more sophisticated and expensive. The major uses of water in the Lake are potable water supply, agriculture, recreation and supporting aquatic life. This paper focuses on a study that was carried out from June 2000 to December 2001 on the influence of sewage discharges on nitrogen and phosphorus loads in the Marimba River. The current paper reports on a part of a broader study on the Marimba River subcatchment focusing on sewage treatment efficiency, effluent polishing via pasture irrigation, and nutrient levels in the Marimba River. This study investigated the contribution of sewage from CSTW and its pastures to the nitrogen and phosphorus levels in the Marimba River. On a broader scope, the study contributed to water resource quality monitoring and assessment, and the development of local information systems to support decision-making.

Materials and methods

The study area

The study area is the Marimba River subcatchment, an area covering 189 km^2 (Fig. 1). The studied area starts from just upstream of sewage discharge points up to the entrance into Lake Chivero. Marimba River stretches for about 25 km originating in the University of Zimbabwe grounds. It flows through the northern and western parts of Harare's commercial centre, collecting surface runoff from low-, medium- and high-density areas. It also flows through the Workington Industrial Area. After collecting sewage effluent from CSTW, the river passes through commercial farming

* To whom all correspondence should be addressed.

☎ +263 23 414 529; fax: +263 4 303288; e-mail: inhapi@eng.uz.ac.zw

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