Nutrient characterisation of river inflow into the estuaries of the Gouritz Water Management Area, South Africa

DA Lemley[1]*, S Taljaard[2], JB Adams[1] and N Strydom[3]

[1]Department of Botany, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth, 6031, South Africa
[2]Council for Scientific and Industrial Research, PO Box 320, Stellenbosch, 7599, South Africa
[3]Department of Zoology, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth, 6031, South Africa

ABSTRACT

This study provides an overview of the nutrient status of river inflow into the estuaries within the Gouritz Water Management Area (WMA) of South Africa. Riverine inputs are a major source of macronutrients to estuaries and the adjacent coastal environments. Long-term water quality monitoring data (dissolved inorganic nitrogen, i.e. DIN; and dissolved inorganic phosphorus, i.e. DIP), collected by the Department of Water Affairs (DWA), were used to assess historical trends of river nutrient inflow within the Gouritz WMA. The results indicate that DIP concentrations exceeded the eutrophic limits for aquatic ecosystems (DWA) in 50% of the catchments assessed. Anthropogenic activities such as agriculture, wastewater discharge, urbanisation, and afforestation were significant factors influencing nutrient levels within these rivers. For the majority of the river systems (approx. 80%) there was no significant correlation ($P > 0.05$) between inorganic nutrient levels and freshwater inflow from the catchments. Wastewater treatment plant (WWTP) data (DWA) were assessed to explore the reasons for this 'disconnect' between freshwater inflow and inorganic nutrient levels. Results indicate that the Gwaing (267.73 $kg \cdot d^{-1}$ DIN; 77.46 $kg \cdot d^{-1}$ DIP), Goukou (49.71 $kg \cdot d^{-1}$ DIN; 17.38 $kg \cdot d^{-1}$ DIP), Knysna (41.77 $kg \cdot d^{-1}$ DIN; 13.92 $kg \cdot d^{-1}$ DIP) and Hartenbos (37.73 $kg \cdot d^{-1}$ DIN; 21.39 $kg \cdot d^{-1}$ DIP) systems received the highest daily loads from WWTPs. The Gwaing and Hartenbos estuaries would be most vulnerable to increased nutrient loading because of their small size and prolonged periods of mouth closure. The study highlights the importance of water quality monitoring of river inflows into coastal ecosystems, as it is needed to assess pollution trends and identify management priorities.

Keywords: Water quality, eutrophication, inorganic nutrients, wastewater discharges

INTRODUCTION

Estuaries form the interface between the marine and freshwater environments and as a result are complex, dynamic and productive ecosystems. Estuaries provide numerous ecosystem services, such as regulating (erosion control), provisioning (food and water), supporting (nursery areas) and cultural services (recreation and tourism) (Costanza et al., 1997; Van Niekerk and Turpie, 2012). Consequently, they are one of the most heavily used and threatened ecosystems worldwide, due to their high socio-economic importance. Water quality and ecological functioning of estuaries closely reflect human activity, not only along the estuarine sector itself, but also within its entire upstream catchment (Billen et al., 2001).

Over recent history, land-use changes in drainage basins/catchments have increased significantly and have led to a considerable transformation from a natural to heavily developed landscape (Fohrer and Chicharo, 2012). This transformation is largely due to the rapid development and intensification of agricultural activities, afforestation, urbanisation, water abstraction, and industrial activities that have had a marked impact on the delicate balance between riverine and coastal ecosystems (Cloern, 2001; Fohrer and Chicharo, 2012). Similar trends are observed in South Africa where all estuaries are subjected to varying degrees and combinations of anthropogenic pressures, whether it is flow alteration, pollution, habitat loss, mining or the exploitation of living resources (Van Niekerk and Turpie, 2012). As a result, the National Biodiversity Assessment of 2011 showed that 42% of estuaries in South Africa are classified as being in fair to poor condition (Van Niekerk and Turpie, 2012).

Coastal ecosystems receive cumulative impacts from their catchments (Fohrer and Chicharo, 2012). This is an important issue to address because land cover changes are expected to have negative effects on the productivity, biodiversity, and ecological functioning of coastal ecosystems (Holland et al., 2004). Anthropogenic manipulation of freshwater affects the physical and biogeochemical balance of estuaries by altering the input, transport, and assimilation of water (i.e. quantity and quality), inorganic nutrients (i.e. N, P and Si), particulate and dissolved organic matter, toxic metals and organopollutants (Buzzelli et al., 2007). The specific responses of different estuarine types to these impacts vary with regards to the composition of the inputs and gradients in geomorphology, physical transport, and internal physical characteristics and biogeochemical cycling (Buzzelli et al., 2007; Buzzelli, 2012).

A great deal of emphasis has been placed on determining the consequences of these anthropogenic stressors on estuaries through the use of monitoring programmes (Carstensen et al., 2012). In South Africa, the Department of Water Affairs (DWA) has co-ordinated an extensive National Chemical Monitoring Programme (NCMP) since the early 1970s, which comprises in excess of 2000 monitoring stations situated in rivers, dams and lakes throughout the country (Huizenga, 2011; Huizenga et al., 2013). Chemical variables that are monitored include: inorganic nutrients (N, P and Si), pH, electrical conductivity, total dissolved solids, as well as a variety of other major chemical

* To whom all correspondence should be addressed.
☎ +27 72 063 1440; e-mail: Daniel.Lemley@nmmu.ac.za
Received 15 January 2014; accepted in revised form 2 October 2014.

http://dx.doi.org/10.4314/wsa.v40i4.14
Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 40 No. 4 October 2014
ISSN 1816-7950 (On-line) = Water SA Vol. 40 No. 4 October 2014