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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Water and the environment

Pollution mapping in freshwater systems

The Water Research Commission (WRC) has completed field tests to evaluate the potential of sewage plume mapping for the monitoring of water quality in natural systems.

Background

The global degradation of both marine and freshwater ecosystems is primarily driven by the excessive addition of anthropogenic nutrients to watersheds. Increased nitrogen loading, for example, can result in widespread ecosystem deterioration and may include harmful algal blooms, large-scale fish kills, hypoxia, the loss of aquatic vegetation and habitat, loss of biodiversity, disruption of ecosystem functioning and the establishment of invasive species.

Reactive nitrogen inputs (N) stem from intensive agricultural land use, resulting in the increased use of N-containing organic and inorganic fertilisers and/or animal manure and their consequent runoff and the discharge of human sewage.

In recent years aquatic ecosystem health has been monitored using a number of techniques, of which the most widely applied in South Africa is the South African Scoring System (SASS 5). Biomonitoring, however, typically identifies eutrophication problems only after ecosystem-level impacts have already occurred and where ecosystem health has been disrupted.

It is often not possible to link biotic changes to identifiable causes (especially in the case of non-point pollution). Any methods that would allow for the detection of emerging eutrophication which can also trace and identify nutrient sources would greatly improve our ability to effectively manage our aquatic resources.

Using stable isotopic values of indicator plants in a particular catchment, it is often possible to determine both the spatial source and the composition of nitrogen sources.

This technique, referred to as a sewage plume mapping, has been used in numerous countries to identify and map the sources, dilution and sinks of nutrients in aquatic ecosystems.

The baseline work for calibrating isotopic response for indicator organism *Spirodela sp.* In response to nutrient concentrations was completed in WRC **Report No. KV 280/11**, during which the need was identified for intensive field tests of the sewage plume mapping technique in the natural environment.

Latest WRC study

The primary aim of this study was to evaluate the potential of sewage plume mapping for the monitoring of water quality in natural systems. Long-term field testing on the New Years-Bushmans River, in the Easter Cape, allowed the mapping of in-situ N dynamics over 13 months, to assess its applicability for the assessment of ecosystem health, the monitoring of temporal variability in N loading, and the identification of incipient eutrophication.

The secondary aim of the study was to compare the isotopic sewage plume mapping technique with the already established SASS 5 biomonitoring technique to determine how well each method described changes in nitrogen dynamic and site health along the Bushmans-New Years river system.

Main results

Transplantation of laboratory incubated plants (with known isotopic ratios) into tethered greenhouse cages at ten sites along the river system was completed in August 2013. Plants were allowed to grow and were sampled for $\delta^{15}N$, δ13N, and C:N ratios every month for 13 months (with a minimum of 10 days between each sampling event). Physico-chemical parameters were collected at every sampling event and SASS5 evaluations and micronutrient analyses were completed quarterly.

Physico-chemistry measurements and micronutrient analyses provided little resolution towards N loading in the Bushmans-New Years River system. ASASS 5 and Shannon-Wiener biodiversity scores showed similar results which broadly agreed with the findings of the sewage plume mapping technique.

Most importantly, however, neither instantaneous measurements of physic-chemistry or SASS 5 scores are designed to identify incipient eutrophication and/or areas of potential concern for monitoring and management interest. Moreover, SASS 5 has a number of limitations, restricting its applicability in a wide range of freshwater ecosystems.

Results from the first comprehensive field test of sewage plume mapping in a South African context are promising, with the combined application of $\delta^{15}N$ values and C:N ratios from transplanted Spirodela plants showing highly dynamic changes in nitrogen within the Bushmans-New Years river system.

Duckweed plants were able to provide a clear time integrated, temporal and spatial map of N loading in the Bushmans-New Years River, identifying sewage/manure and fertilizer inputs. Moreover, this technique identified areas and time periods where adjacent sewage inputs appear to be leaking into the river system and these sites (and times) should be tagged for management interest.

Conclusions

Sewage plume mapping combines a quick assessment of ecosystem health, provides a spatial and temporal map of N loading hotspots over a ten-day integration period and has the ability to classify anthropogenic loads from different N sources (e.g. sewage/manure or synthetic fertilizer).

It is a versatile tool for the monitoring and assessment of ecosystem health which provides more resolution than current biotic indices. Its application will allow us to identify dynamic changes in nitrate and ammonia within a river system, help to correlate water chemistry with nutrient loading and broaden our understanding of the consequences of eutrophication in freshwater systems.

Moreover, $\delta^{15}N$ and C:N values should allow for the mapping and identification of pollution hotspots and gradients which may identify areas of particular management interest. Using $\delta^{15}N$ and C:N ratios, potentially in combination with other chemical parameters, we may be eventually able to predict the ultimate sources of N pollution, which will aid in the conservation, rehabilitation and management of South Africa's waterways.

Further reading:
To order the report, ***Pollution mapping in freshwater systems: Using aquatic plants to trace N-loading*** (**Report No. 2262/1/15**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.