WATER RESEARCH COMMISSION

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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 quality

Sediment as a physical water quality stressor

A completed WRC-funded study explored sediment as a physical water quality stressor on macro-invertebrates as a contribution to the development of a water quality guideline for suspended solids.

Background

Although the ecological consequences of high sediment loads in rivers have been long recognised, appropriate methods of managing instream particulates based on biological effects data have been problematic to develop.

Exposure-response relationships derived from unspecified natural sediments have possessed unacceptably high variability, making them unreliable predictors of biological effects.

Recently, there has been recognition that specific characteristics of particulates can affect the severity of biological effects (e.g. particle size, shape and geochemical composition) and, consequently, that the exsposure-response relationships used to produce water quality guidelines will have to be more situation-specific, aimed at a restricted combination of the above mentioned particle characteristics.

The Department of Water & Sanitation has undertaken to revise the South African water quality guidelines for fresh waters, and update the current guideline for instream particulates with one based on biological effects. Research undertaken in this WRC-funded project represents the start of work toward providing appropriate biological response data in this regard, and the beginning of investigations into improving the management of this aquatic ecosystem stressor.

Generating an exposure-response relationship framework

Biological effects data were collated from an extensive search of the international scientific literature, with some additional indigenous South African data generated during the course of this project. Most lethal point-estimate data were for marine species, which appeared to be extremely tolerant of suspended kaolin particles (the focus of this project).

Nevertheless, these data were applied to a species sensitive distribution (SSD). There were very few studies reporting sub-lethal endpoints in the form of no observed effect concentration (NOEC) or sub-lethal point-estimate (ECx) data. Still, the available six NOECs and one EC25 data point (of varying exposure periods) were also applied to an SSD.

In the absence of sufficient traditional exposure-response data (point-estimates or NOECs) to derive reliable water quality guidelines for suspended solids, a number of attempts have been made by researchers to characterise the exposure-response relationship for freshwater and estuarine fishes as empirical models composed of three variables: suspended particular concentration; duration of exposure; and severity-of-effect. The data collated as part of this project were applied to this type of exposure-response relationship as well.

The exposure-response relationships generated for kaolin suggest that sub-lethal effects at concentrations below 30 mg/ℓ and lethal effects at concentrations below 55 mg/ℓ, over extended periods of exposure are unlikely to occur for all but the most sensitive species.

In terms of short-term exposures (< 24 hours), the freshwater macroinvertebrates tested were very tolerant (no mortalities at the highest concentrated tested of 801 mg/ℓ). however, marine fish larvae were much more sensitive.

Developing a detailed site-specific suspended solids risk assessment protocol

A suspended solids risk assessment framework was developed with the purpose of determining if instream suspended particular matter concentration at a site, or within a specific region, are having unacceptable effects on the resident biota.

A three-tiered approach was proposed:

- **Tier 1**: A 'desktop' approach in which the geospatial characteristics within a catchment are used to determine the potential for unacceptable biological effects from suspended particular matter.
- **Tier 2**: A comparison of sediment load characteristics (turbidity and suspended solids concentrations) measured in the field with a relevant biological effects exposure-response relationship generated from laboratory data in order to infer the potential for unacceptable biological effects from suspended particulate matter.
- **Tier 3**: Site-specific biomonitoring of biota resident at a site in order to directly measure for unacceptable biological effects from suspended particulate matter.

This approach required that two assumptions be met for Tier 1: 1) there is a link between a geospatial characteristic and a sediment load characteristic and 2) there is a link between a particular sediment load characteristic and macroinvertebrate assemblage response.

It also required that two questions be answered for Tier 2 and Tier 3 respectively: 1) which sediment load characteristic best predicts biological (macroinvertebrate) changes in the field (so allowing effort in developing a water quality guideline to focus on that particular sediment load characteristic) and 2) which biological response variable is a sensitive measure of particulates exposure and should therefore be employed in site-specific biomonitoring? Five hypotheses were designed to address these assumptions and questions and were investigated in a field study.

The aim of the field study was to examine hypotheses that could be used to test and refine the application of the proposed suspended solids risk assessment protocol. Hypotheses 1 and 2 were undertaken to ensure that there were indeed differences between sites/catchments in terms of geospatial and sediment load characteristics respectively, allowing the third hypothesis to specifically investigate assumption 1 of Tier 1.

Results indicated that during low flows the land class of 'cultivation', when close to the river (within 1-2 km), had a strong negative correlation with instream turbidity and total suspended solids (TSS). At higher flows the land classes of 'degradation' and 'cultivation', erosion gully measures and measures of higher population density had a strong and consistent positive correlation with instream turbidity and TSS.

The 'natural' land class had a strong negative correlation with instream turbidity and TSS. During the higher flows, the number of significant correlations measured between geospatial and sediment load characteristics was considerably higher when a restricted sub-catchment radius of 20 km from sampling sites for geospatial data was used, instead of using geospatial data from the whole catchment.

Settled solids concentrations were positively correlated with erosion gullies occurring within 3 km of the river site. Consequently, the first assumption, that there is a link between certain geospatial characteristics and certain sediment load characteristics could be confirmed, although flow/rainfall season and the type of sediment characteristic chosen can affect the most suitable geospatial characteristic.

Conclusions

The limited number of macroinvertebrates samples collected during this study means that any conclusions should be viewed as promising leads for further investigation. Given this, further refinement of the risk assessment protocol should focus on the geospatial characteristics found significant in this study: the land cover classes of 'natural', 'degraded' and 'cultivation', measures of erosion gullies, and measures of population density.

Furthermore, settled solids should be investigated in order to confirm the importance of this sediment load characteristic over suspended solids in causing aquatic ecosystem effects.

Further reading:
To order the report, *Sediment as a physical water quality stressor on macro invertebrates: A contribution to the development of a water quality guideline for suspended solids* (**Report No. 2040/1/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.