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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

Climate change

Climate change and water quality

A completed WRC-funded project investigated the effects of projected climate change on eutrophication and related water quality as well as secondary impacts on the aquatic ecosystem.

Background

Chemical and biological characteristics of water in rivers are defined by dissolved materials as well fauna and flora. Organic material, which causes oxygen deficiency in water bodies; nutrients, which cause excessive growth of algae in lakes, rivers, dams and coastal areas that is known as eutrophication (leading to algal blooms, which may be toxic and consume large amounts of oxygen when decaying); and toxic heavy metals and organic compounds are some of the main water pollutants.

Studies and model predictions indicate that climate change will most likely lead to an increase in temperature that may among others result in increased algal blooms due to nutrients such as phosphates from industrial or municipal waste.

Hence, a WRC-funded project sought to improve understanding of the impact of potential climate change on water quality for improved management of water resources. Deteriorating quality of water in dams and rivers due to, among others, nutrients and increased temperatures has socio-economic, environmental and health effects on the ecosystem goods and services.

Accordingly this project was also aimed at determining drivers of the impacts and recommending appropriate measures to deal with them. On the other hand, research indicates that the extent of eutrophication has increased in South African water bodies since its discovery in the 1970s, increasing the problems of high concentrations of algae and reduced water quality. Hence, the project also investigated the impacts of climate change on eutrophication and determined effects of resultant decreased dissolved oxygen on the aquatic ecosystem.

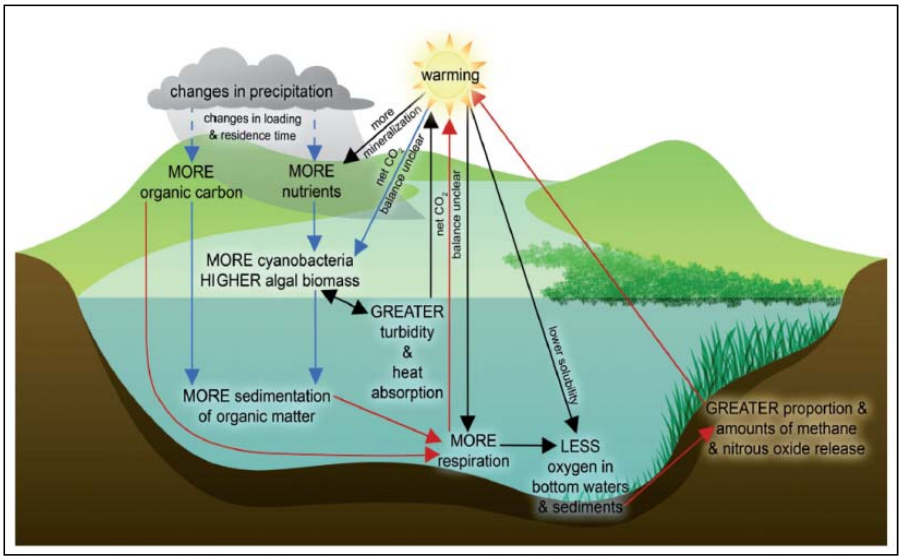

***Figure 1**: Current indications of feedback effects of eutrophication on climate change. (Moss et al., 2011)*

Methodology

The project team undertook an extensive literature study, interviews with experts and various stakeholder workshops and modelling. Some of the key activities included use of downscaled General Circulation Models (GCMs) to project changes in rainfall and temperature under A2 climate scenarios across the country at Quinary catchment level. This information was used as a basis for the identification of impacts on the selected case study systems.

Findings

The final report summarises the water quality modelling exercises carried out for this project, provides an investigation into the impacts of these changes, and provides recommendations for adaptation and mitigation options.

Some of the key findings were that human activities are the main causes of eutrophication, as increased concentrations of phosphorous and nitrogen are discharged into water bodies. These water bodies respond directly to climatic changes, and the variability in these responses is likely to affect water resources, water quality and aquatic ecosystems.

Also, a significant influence on oxygen concentrations is temperature – higher temperatures reduce the solubility of dissolved oxygen, thereby decreasing dissolved oxygen concentration. Higher temperatures also promote microbial action, and in turn the increased photosynthesis and respiration further reducing dissolved oxygen concentration.

As the temperature increases due to projected climate change, the solubility of oxygen is likely to decrease when evaporation rates increase, further decreasing the oxygen solubility. Thus decreased dissolved oxygen impacts negatively on aquatic ecosystem.

The case studies (modelling) were undertaken at 3 sites using the CE-QUAL-2 model (for the Berg River Dam and Voelvlei Dam) and the QUL2K model (for the Vaal River). Figure 3 depicts summary of the results.

The variability among climate models used in this project is recognised, and the importance of using an ensemble of validated climate change models is therefore highlighted. All models however, projected an ***increase in air temperatures*** for each of the time projections studied, and based on both of the modelling exercise concluded that air temperature is the major driver for surface water temperature, which is the parameter that strongly drives algal growth.

Conclusions and recommendations

Both Midvaal Water Company and Sedibeng Water have good monitoring programmes along the Vaal River, and in particular include the monitoring of water temperature and chlorophyll-A, which can be used for eutrophication modelling.

These comprehensive monitoring programmes can add significant value to water resource management. Hence, monitoring and measuring of the channels into and out of the country's major dams and rivers should be implemented to allow for more accurate modelling exercises.

This should include both flow and water quality constituents. The parameters that govern algal growth should furthermore be measured in a laboratory or ***in situ.***

This would also provide a quantitative analysis on the sensitivity of certain parameters as well as their effect on

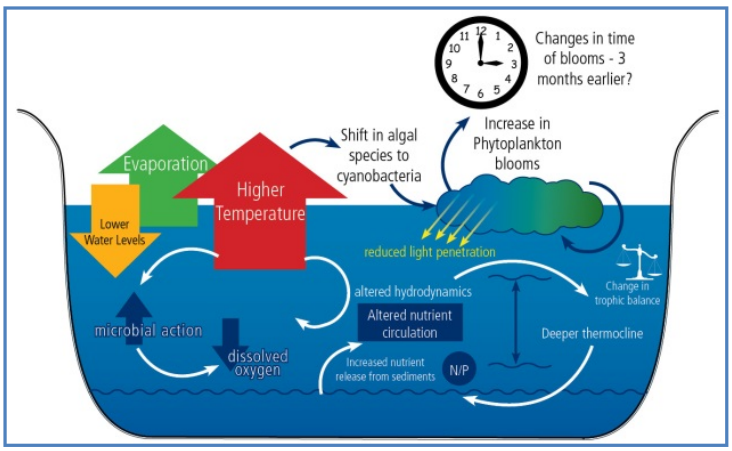

Figure 2*: Simplified diagram of the interactions between climate change, nutrient release and algal prevalence.*

Case Study		Berg River Dam		Voëlvlei Dam		Vaal River	
Model Used		CE-QUAL				QUAL2K	
Climate change projection dates		2046 - 2065	2081 - 2100	2046 - 2065	2081 - 2100	2046 - 2065	2081 - 2100
Parameter modelled	*Phytoplankton*					↑	↑↑
	Diatoms	↓≠	↓≠	↑≠	↑≠		
	Green algae	-		↑≠	↑≠		
	Blue-Green algae	-		No strong trend, ≠			
	Total algae	No trend, ≠		↑≠	↑↑≠		
	Zooplankton	↓	↓	↑	↑↑		
	Water temperature	↑	↑	↑	↑	↑	↑↑
	Flow (river)/Level (dam)	↓	↓↓	↓	↓	↓	↓
	Dissolved oxygen	↓	↓	↓	↓	↓	↓↓
	Orthophosphate	Unchanged		↑	↑		
	Ammonium	↓	↓	↑≠	↑↑≠		
	Nitrate/nitrite	No trend		No trend, ≠			
	Dissolved silicon	↓	↓	↑≠	↑↑≠		

↑	increase (↓↓ - approximately double magnitude of the increase into the distant future)
↓	decrease (↓↓ - approximately double the magnitude of the decrease into the distant future)
-	Species does not establish
≠	Seasonal shift
	Not modelled

Figure 3: Summary of modelling results

dissolved oxygen concentrations. Sedimentation data should be measured and incorporated and the simulation rerun to investigate this effect on the eutrophication rate and subsequent water quality.

It is also recommended that collaboration and alignment of activities among Government departments, private sector and communities should be encouraged. Other important considerations for improved water management given climatic effects and other stressors include compliance monitoring and enforcement, awareness raising as well as capacity building.

Further reading:
To order the report, *Investigation of the effects of projected climate change on eutrophication and related water quality and secondary impacts on the aquatic ecosystem* (**Report No. 2028/1/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.