Phosphorus retention and metabolism: indicators of stream deterioration across a rural-urban gradient?

by

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List of abbreviations

Benthic organic matter	BOM
Coarse particulate organic matter	CPOM
Community respiration	CR
Decay coefficient	•
Dispersion coefficient	D
Dissolved organic carbon	DOC
Filterable reactive phosphorus	FRP
Fine particulate organic matter	FPOM
Gross primary production	GPP
Mass transfer coefficient	v_f
Net ecosystem production	NEP
Net primary production	NPP
Production rate	•
Retardation factor	R
Stream velocity	v
Total carbon	TC
Total nitrogen	TN
Total phosphorus	TP
Uptake length	S_w

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I consent to the thesis being made available for photocopying and loan if accepted for the award of the degree.

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Kane Thomas Aldridge

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Summary

Much attention has been paid to the effects of anthropogenic impacts upon physical and chemical conditions in freshwater ecosystems. However, impacts upon the functioning of these ecosystems and services that they provide remain relatively unknown. The objective of this thesis was to examine the validity of the general hypothesis that the deterioration of ecosystems may be reflected in their capacity to process resources.

Changes in stream phosphorus retention and metabolism were investigated across a rural-urban gradient in the Torrens River Catchment, South Australia, where channel structures of rural reaches are less modified than urban reaches. In a stream with an intact upper rural catchment (First Creek), a reach with an un-modified channel structure retained 60% ± 12.1 filterable reactive phosphorus (FRP) and had an average uptake length of 79 m ± 3.4. In comparison, degraded and engineered reaches of First Creek retained less FRP and had longer uptake lengths. In Fourth Creek, which is influenced by agriculture, there were no differences in FRP retention between the reaches. Reduced FRP retention in impacted reaches were a result of decreased contact time, reduced period of continuous flow and increased nutrient availability. Although abiotic benthic FRP uptake rates (up to 6.8 •g m^{-2} s^{-1} ± 0.36) were consistently greater than biotic uptake rates (up to 3.6 •g m^{-2} s^{-1} ± 0.52), decreased total benthic uptake rates in impacted reaches were mainly due to decreased biotic uptake.

Metabolic rates were measured within benthic chambers containing rocks and gravel and scaled up to the stream reach. At chamber and reach scales, metabolic rates in the un-modified reach of First Creek were consistently low (community respiration (CR) up to 113 mg O_2 m^{-2} day^{-1} ± 47.4 and gross primary production (GPP) up to 234 mg O_2 m^{-2} day^{-1} ± 89.5), with a positive net ecosystem production (NEP). In comparison, the degraded reach of First Creek switched between having a negative and positive NEP. Reaches of Fourth Creek also experienced considerable variation and had higher metabolic rates than First Creek (CR up to 371 mg O_2 m^{-2} day^{-1} ± 62.1 and GPP up to 847 mg O_2 m^{-2} day^{-1} ± 66.1). Increased metabolic rates in impacted reaches were attributed to increased light availability and reduced grazing by higher trophic levels, promoting autotrophic organisms.

The altered ecosystem functions were considered to reflect a reduced capacity of deteriorated streams to process resources. However, the addition of coarse particulate organic matter to a degraded-urban stream reach increased CR and reduced NEP to levels more akin to those experienced within pristine streams. Furthermore, percent FRP retention increased, primarily through increased demand for phosphorus of the microbial community.

Although this demonstrated that rehabilitation of in-stream attributes might restore important ecosystem functions in impacted streams, successful restoration will only be achieved if the over-riding causes of in-stream degradation are addressed.

Foreword

This thesis has been prepared as a series of chapters in a format that will be suitable for future publication in scientific journals. To maintain the sense of individual chapters, this has inevitably led to some repetition between chapters.