The transport and accumulation processes of geochemical tracers in environmental compartments

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under the supervision of Daniel Ramp, Qiang Yu

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Certificate of Original Authorship

I, Jianguo Li declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Life Science/Faculty of Science at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.
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Publications arising from this thesis

Journal papers directly included in this thesis

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Contents

List of Figures

List of Tables

Glossary

AIC	Akiake Information Criterion
ANOVA	Analysis of variances
APCS/MLR	absolute principal component score/multiple linear regression
BJD	Badain Jaran Desert
DEM	digital elevation model
EC	electric conductivity
EMMA	End member mixing analysis
GAM	generalised additive models
GBM	gradient boosted machine
GDAS	Global Data Assimilation System
GLM	generalised linear models
GMWL	global meteoric water line
GNIP	Global Network of Isotopes in Precipitation
GPCC	Global Precipitation Climatology Center
HM	heavy metal
HRB	Heihe River Basin
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
LMM	linear mixed models
LMWLs	local meteoric water lines
MLR	multiple linear regression
MODIS	Moderate Resolution Imaging Spectroradiometer
NCEP/NCAR	National Centers for Environmental Prediction/National Center for Atmospheric Research
NDVI	normalized difference vegetation index
OLR	outgoing longwave radiation
PCA	principal component analysis
PMF	positive matrix factorization
QTP	Qinghai-Tibet Plateau
RDA	Redundancy analysis
RF	random forest
SDM	species distribution model
TDS	total dissolved solids
TEM	transmission electron microscopy
TPI	Topographic Position Index

TRI	Terrain Ruggedness Index
WCP	water chemical parameters
ZMSK	Zhamashike

Abstract

The ubiquitous geochemical tracers tend to persistently transport and accumulate in different environmental compartments, and a better understanding of geochemical tracer transport mechanism is essential for conservation and resource management. In this thesis, systematic data sets were collected from many typical environmental compartments both in China and Australia, including the catchment, desert, and typical mining sites at an alpine stream etc. Various geochemical tracers and methodologies, such as heavy metals and stable isotopes were applied to make a comprehensive exploration of the interactive impacts of human activity and natural processes on the transport and accumulation of geochemical tracers. The main findings of this thesis are:

(1) The species distribution model (SDM) can help improve the prediction accuracy of mapping geochemical tracers by considering the important explanatory variables. The prediction results of Chapter 2 and Chapter 3 confirmed the effectiveness and potential of leveraging SDMs from ecology to study heavy metal contamination in the field of hydrology, which offered new insights to understand the relationships between HMs and the human and physical environment.

(2) The combinations of interdisciplinary, multi-methods, various geochemical tracers, and indicators, facilitate the improvement of discovering the transport processes of tracers. In Chapter 3, the end member mixing analysis (EMMA) and SDM were combined to study the vertical hydraulic connections between surface water and groundwater. The water chemical tracers in river water were found to be able to serve as good explanatory variables to predict the HMs in soil in Chapter 4. And both elemental concentration and bioaccumulation ratio were used as the indicators to study the bioaccumulation processes in Chapter 6, which can provide more detailed information, otherwise the spatial attributes of the geochemical background information will be ignored. All these results supported this perspective.

(3) The model selection and model averaging methods constitute an advancement in quantitatively interpreting the relationships between isotopic signatures of precipitation and their local climatic variables. This method can supplement or precede more complex studies of hydrological cycles utilizing isotope tools.

Overall, the combination of various chemical tracers, as well as the introduction of powerful methodologies from related research fields, can effectively help improve the analysis accuracy. This thesis offers an improved understanding of the transport and accumulation of chemical tracers between different environmental compartments, and can provide useful

database at the data scarce areas. The results of this thesis can also provide scientific strategies for the regional development and management.

Keywords: environmental compartments, carriers, geochemical tracers, bioaccumulation, catchment, hydrological units, mining activity, spatial distribution models, model selection, arid and semi-arid regions, China, Australia