PHASE TRANSITIONS OF TRACE METALS IN THE AQUATIC ENVIRONMENT OF KUTTANAD, KERALA

A THESIS SUBMITTED TO
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Doctor of Philosophy
IN
Environmental Chemistry
UNDER THE FACULTY OF MARINE SCIENCES

By

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DECEMBER 2000

CERTIFICATE

This is to certify that this thesis is an authentic record of the research carried out by Shri. P. Unnikrishnan, under my supervision and guidance in the Department of Chemical Oceanography, School of Marine Sciences, Cochin University of Science and Technology, in partial fulfilment of the requirements for the degree of ***Philosophiae Doctor*** of the Cochin University of Science and Technology.

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PREFACE

Environmental persistence, fate and interactive effects with living organisms - beneficial or toxic - of trace elements are directly related to the physico-chemical forms in which they occur. Knowledge on the association of trace metals with different environmental compartments in an aquatic system are, therefore, essential for monitoring the trace metal pollution as well as transport, fate and bio-geochemical cycles of trace metals. This thesis is a modest attempt in assessing the trace metal levels and their behaviour in the aquatic environment of Kuttanad, an aquatic system that is severely affected by man's intervention on natural processes, by seriously evaluating the levels of trace metals in dissolved and particulate phases and also in the different chemical fractions of the sediments.

Understanding of the distributions, variations and transfer processes of trace metals in different environmental phases in the backwaters of Kuttanad is vital for the assessment of water pollution problems and study of the ecology of the area which contributes 20% of the rice production in the State of Kerala. Eventhough considerable amount of study has been done on the distribution of trace metals in the Cochin estuary, no data are available on the distribution of trace metals in the backwaters of Kuttanad, which is a continuation of Cochin estuary and forms the southern upstream part of Cochin estuarine System.

The thesis has been divided into 7 Chapters.

Chapter 1 gives a brief description about the estuarine environment with special reference to trace metals. The features of Kuttanad region and an update on scientific information about trace metals in the Cochin estuary are provided in this Chapter along with the aim and scope of the present study.

Chapter 2 gives the description of the study area, sampling procedures for water and sediment, and the various analytical techniques employed for the determination of different parameters. Chapter 3 presents the general hydrographic characteristics viz. temperature, depth, pH, salinity, dissolved oxygen and suspended solids. Concentrations of dissolved major ions like magnesium, calcium, strontium, barium and boron, and data recorded on the sediment characteristics like moisture, texture and organic carbon are also included in this Chapter. The seasonal and spatial variations observed have been critically analysed in relation to the varying estuarine conditions. The inter-relationships between dissolved major ions and environmental variables like chlorinity are also discussed.

Chapter 4 reports the temporal and spatial variations in the distributions of ten dissolved trace metals viz., cadmium, cobalt, copper, chromium, iron, manganese, molybdenum, nickel, lead and zinc. The fluctuations in the concentrations of trace metals during the different seasons of the year are explained against the background of the physico-chemical features and the combined effects of domestic and industrial inputs. Chapter 5 describes the distribution of trace metals associated with particulate phase. Seasonal and spatial variations in the concentrations of particulate trace metals are discussed in this Chapter. The inter - relationship with other environmental parameters along with the partitioning of trace metals between water and suspended solids are discussed.

Chapter 6 discusses the cyclic behaviour in the distribution of total sediment associated trace metals viz., cadmium, cobalt, chromium, copper, iron, manganese, molybdenum, nickel, lead and zinc. Sequential chemical extraction experiments for estimating characteristic association of different forms of trace metals and their mobility in sediment are also dealt in this Chapter. The major fractions identified are exchangeable fraction, Fe-Mn oxide bound fraction and the residual fraction, which includes organic bound fraction also. The data on the partitioning studies of sediment associated trace metals provide information on the relative changes of elemental phases and thereby an insight into the diagenetic processes taking place after deposition of the sedimentary components. The above data are also used for the assessment of trace metal mobility in the backwaters of Kuttanad region.

Chapter 7 portrays a flow reactor model of the study area based on the principles of steady state approximation taking into account of the various equilibrium existing between the environmental compartments for the resolution of the complexities that determine the trace metal fluxes.

A list of references is included at the end. The monthly values of various parameters are appended at the end due to their exhaustive nature and is removed from the text, while the corresponding figures depicting the annual mean variations, seasonal variations, zonal variations, summary statistics and the various derived parameters are included in the text itself.

CONTENTS

CHAPTER 1

INTRODUCTION

"Estuaries are a happy land, rich in the nutrients of the continent itself, stirred by the forces of nature like the soup of a French Chef, the home of myriad forms of life from bacteria and protozoan to grasses and mammals: the nursery, resting place and refuge of countless species" – Stanley. A. Cain.

To those of us who enjoy the ocean, an estuary is simply a place where the incoming ocean meets flowing rivers and streams, forming mudflats and marshes. As freshwater meets the ocean, both land and ocean contribute to a beautiful and fragile ecosystem. They are crucial transition zones between land and water that provide an environment for lessons in biology, geology, chemistry, physics, history and social issues. Since colonial times, we have used estuaries and their connecting network of rivers for transporting agricultural goods for manufacturing and trade. Estuaries, in short, are natural treasures – vital ecological and community resources – whose health affects our health and the vibrancy of our communities and economy.

Estuaries are one among the highly productive ecosystems, accounting for one-half of the living matter of the world's ocean. Unfortunately, these ecosystems usually bear the brunt of human waste and contamination because they were and are the first areas of human settlement. Organic effluents such as domestic sewage is s serious problem - the discharge of small quantities of sewage into estuarine systems can actually increase the productivity of the ecosystem, but excessive quantities will deplete oxygen - causing severe threats to aquatic life. Industrial wastes, with its large load of heavy metals, can be toxic even at low concentrations. Estuaries receive all materials coming from the river catchments This material, fine sediments,