METAL CONTAMINANTS IN NEW ZEALAND

Metal Contaminants in New Zealand

Sources, Treatments, and Effects on Ecology and Human Health

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PREFACE

Humans, since the earliest civilizations, have relied on metals for various uses, from decorative dyes, medicines, and weapon fashioning, to tools and currency. Eras in our civilization are even defined by metals (think Copper Age, 10,000 BC; Bronze Age, 4,500 BC; and the Iron Age, 500 BC). Since the "Industrial Revolution", metal extraction, production and utilisation have provided us with everything from shoe rivets and belt buckles to whiteware and cars, roofs of our homes, and the wiring that enables communications and power.

Metals also play a more direct and key role in human as well as plant and animal health. During our lifetime each of us will have consumed many grams of metals in order to function as a healthy being. For example, iron, a ubiquitous metal, is crucial to humans and animals for transporting oxygen around the body. The average adult human has approximately 2.4 – 3.6 grams of iron sourced mostly in the haemoglobin (a protein contained in the blood that gives the blood its 'red' appearance) that provides our organs with life-sustaining oxygen.

However, living organisms are able to tolerate only a relatively narrow range of metal concentrations, and the demarcation between healthy and toxic amounts is often sharp. Metal toxicity depends on the physical and chemical form of the element, and on its bioavailability and distribution, storage and excretion in the body. Yet the way by which metals exert their chronic toxic effects on biological organisms is not completely understood. The most important mechanisms appear to be those of accumulation and those resulting from irreversible toxic effects. It has been recognized for many years that large areas of the globe contain regions naturally elevated in trace elements that have resulted in metal excess, deficiency, or chronic poisoning in people and organisms that inhabit these places. More recently, considerable interest has developed in assessing the human health risk posed by metals, metalloids, and trace elements in the environment.

Although our society has long placed economic value on metals, health issues have been recognized only in stages. Early examples of metal poisoning were documented more than 2000 years ago but were not well understood. However, by the 17th century it was realized that the lead in pewter tankards used for storing beer and wine was the cause of poisoning of many custodians and patrons of public establishments. Mercury, another well-known metal, was used extensively and cases of poisoning were not uncommon. One famous example concerned the effects of its use in fur felting for hats. Over time the hat maker's blood mercury content was raised sufficiently to result in brain damage, giving rise to the 'Mad Hatter' expression of *Alice in Wonderland* notoriety.

This book addresses specific issues regarding the role of metals and metalloids in both the New Zealand and global environment. Sources of metal contaminants – both natural and anthropogenic ones – are explored, as well as the impacts of these contaminants upon local ecology and human health. Specific case studies from New Zealand and other countries are presented.

As researchers in these fields, we felt that a reference book that addressed metal contaminants in the New Zealand environment was timely. This book is intended for students, regulators, policy makers and readers who have little or no previous knowledge of the effects of metal contaminants in the environment or their possible treatment. Although there have been many overseas studies on the release, dispersal and ultimate environmental impacts of metals, this book provides the first compilation of New Zealand examples. The book is arranged in five sections. The first section consists of two **Background** papers (*Cavanagh and Coakley; Finkelman*) and gives the reader an insight into the New Zealand regulatory system for metals and metalloids as well as a general review of sources of metals. The second section details the **Natural and Anthropogenic Sources** of metals and metalloids (*Ward et al.; Moore et al.; Pope et al.; Falconer and Craw; Martin; Taulis; Webster-Brown; Webster-Brown and Craw; Craw et al.; Black et al.; de Joux and Moore*). The purpose of this section is twofold: firstly, to give the reader some specific knowledge of how and in what concentrations some metals reside naturally in our environment; and secondly, to identify how some metals get into our environment as a result of human intervention, e.g. disturbance of the land or by various production processes. The third section, **Environmental Remediation** (*O'Sullivan; Chagué-Goff; Trumm et al.*) outlines some remediation technologies for treating effluents rich in metals. The final two sections describe the effects of metals. Two papers in the fourth section (*Harding; Boothroyd et al.*) consider the **Effects on Ecology** of metals, specifically from mining activities. The final section, **Effects on Human Health** (*Luckman and Slaney; Gray et al.; Centeno et al.; Phillips and Fowles; Cook and Weinstein*), looks at how exposure to metals and metalloids such as arsenic can affect our quality of life, whether the source be local and specific, e.g. in our workplace, or more general, e.g. volcanic sources.

Our aim has been to provide the first compilation of references illustrating the specific effects of metal contaminants in the New Zealand environment. This collection is not a complete review of our understanding of metals, and the focus of chapters on specific issues indicates the main areas of research within New Zealand. While great effort was made to provide a wide variety of material there will be some omissions. We hope that by compiling these works of our peers and colleagues, we may initiate a further drive for reference books of this nature. It is only through dissemination of information and understanding that sound environmental management decisions can be made.

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INTRODUCTION

Our planet provides the environment for our lives and as such has an important bearing on our health and well being. Perhaps many of us take for granted that nature provides a clean environment. Perhaps many of us do not even think of our natural environment as important for our health, but it certainly is. The health of billions of people all around the globe is affected by our natural environment, that is, geology.

Metals and other elements have always existed and will forever exist, but we cannot avoid and ignore the fact that all humans and animals can be affected by them in both positive and negative ways. Some are necessary for our well being and others are detrimental to our health. Chemical elements are present in soils and rocks. Whether emanating from our natural environment or human activities, they are ingested via food and water, inhaled by air, and thus influences our health.

In recent years, considerable interest has been developed in assessing the risk posed by metals and trace elements in environmental quality and human health. An emerging field, termed 'Medical Geology' has developed to address these risks. It has been recognized for many years that large areas of the globe contain naturally endemic areas related to trace element excess, deficiency, or chronic poisoning. Many of these health-related problems have been associated with geological sources (e.g., contaminated drinking water, coal use, volcanic eruptions, dust, etc), but also anthropogenic sources. For example, the occurrence of endemic goiter and cretinism have both been associated with iodine deficiency in several areas of the globe. Selenium deficiency has been related with cases of muscular dystrophy as well as the induction of endemic cardiomyopathy. Excess of fluorine in drinking water has also been associated with endemic dental and skeletal fluorosis in several geographical areas. Well-documented cases of chronic arsenic poisoning from consumption of drinking water are known in southern Taiwan, Chile, Argentina, Mexico, China, and recently in West Bengal and Bangladesh. Accordingly, an understanding of the nature and magnitude of environmental, geological and anthropogenic sources is a prerequisite for developing approaches in assessing the risk posed by metals, metalloids, and trace elements.

Also medical geology addresses other sources that may cause severe health problems. Ash ejected from volcanic eruptions can travel many times around the world and recent satellite images have shown wind blown dust picked up from the Sahara, Gobi and Australian deserts blown halfway around the world. Exposure to these dusts can cause a wide range of respiratory problems. Other topics addressed are the environmental and health problems associated with mining practices.

Understanding the potential environmental and health effects of metals and other elements is of critical importance in order to: 1) ensure that metals are produced, used and disposed of in environmentally sound ways; 2) to minimize exposure to toxic levels by the development and implementation of scientifically sound environmental regulations; and 3) to develop appropriate analytical techniques for the study and determination of low-levels of toxic metals and metal species. *Metal Contaminants in New Zealand* has been created to address each one of these important subjects. Reputed scientists from various organizations have contributed. Some of the authors are also involved in the new association, International Medical Geology Association. The book gives an important overview of metal contaminants in New Zealand and provides a comprehensive and interdisciplinary approach to the study of the natural environment (geology) on its potential effects on environmental quality and public health. Although the focus is on New Zealand, the conclusions drawn can also be used in other countries and in the global scale.

Emphasizing a holistic approach, *Metal Contaminants in New Zealand* offers the reader a broad sweep of topics which are relevant to environmental health sciences, medical geology and public health protection, from general chapters on basic knowledge to in-depth papers covering natural and anthropogenic sources, remediation, effects on ecology, risk assessment, and effects on human health. Therefore, it is anticipated that the publication of this book will provide a comprehensive and multidisciplinary platform to a worldwide readership with interest in learning more about the interactions of the natural environment and public health.

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