

Shabnum Nabi

# Toxic Effects of Mercury

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 Springer

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*The largest pond is as sensitive to atmospheric changes as the globule of mercury in its tube.*

(Henry David Thoreau)



*Dedicated to my parents and brothers for their endless  
affection and support*



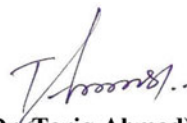


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## Foreword

It gives me immense pleasure and delight when I received a request from *Dr. Shabnum Nabi* to write a brief foreword to the book entitled *Toxic Effects of Mercury* written by her under the auspices of Springer publishing house. The work she has produced throughout these years in the form of books, book chapters and research papers is not only commendable but informative for one and all. The book deals with mercury toxicity and its ill hazards to our environment in general and humans in particular with a prime focus on oxidative stress in the degeneration of nervous and non-nervous tissues. The book further throws light on the severity of mercury through consumption of contaminated fish and other food products. It is worth to mention over here that methylmercury became a prime environmental health issue during 1950s. In spite of decades of research, the toxic mechanisms of methylmercury still remain an enigma. This book, therefore, has a wide scope, utility and potential as mercury is being used in agriculture, forestry and many potential industries, especially cosmetic industry.

In short, it is surely a work to treasure and valuable source of information for medical practitioners, toxicologists, clinical biochemists, researchers, scientists, and general public in particular.



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## Preface

The words of Mercury are harsh after the songs of Apollo.

(William Shakespeare)

Mercury is among the best known most puzzling metals in the environment. It is a unique element that, unlike many metals, has no biological function. It is liquid at room temperature and is 13.6 times heavier than water. It occurs in all media in several forms, both organic and inorganic. It is relatively uncommon in the Earth's crust, from which it is liberated by natural processes such as erosion and volcanism as well as by mining. All mercury compounds are toxic to humans and animals, but the organic forms, particularly methylmercury and dimethylmercury, have the highest toxicity. Methylmercury is the form found most widely in nature, and it bioaccumulates in the food chain. It is the form to which most human exposure occurs. Mercury has potent compromising effects upon the immune system and is also associated with chronic overgrowth of *Candida*, anemia, forgetfulness, tremors, depression, drowsiness, insomnia, headache, loss of energy etc. Chronically its toxicity causes low body temperature, bleeding gums, loosening of teeth and other mouth sores, sore throat, joint pain, high blood pressure, nutritional disturbances, urinary disturbances etc., to list just a few of the 42 conditions identified. Mercury poisoning is involved in five categories of pathology: (1) neurological diseases, (2) cardiovascular diseases, (3) collagen diseases, (4) immunological diseases, and (5) allergies.

Many of us vividly recall the devastating effects of point source of mercury (Hg) pollution in Minimata Bay, Japan, documented by poignant photos of mothers caring for their children afflicted with crippling deformities. From 1952 to 1968, Hg waste from the production of acetaldehyde and vinyl chloride was discharged (200–600 t) into Minimata Bay. This resulted in Hg bioaccumulation by marine fish and shellfish, biomagnification in the marine food web, and subsequent ingestion by humans. Although this was perhaps the most severe case in history, the processes determining the fate of Hg in the environment are common to all aquatic ecosystems.

The Minimata catastrophe also revealed that the neurotoxicological effects on fetal development from pregnant women ingesting Hg-contaminated fish could be especially severe. This finding, as well as research over subsequent decades on the process of Hg bioaccumulation and biomagnification in aquatic and marine ecosystems, has led to today's warnings by many public

health agencies about pregnant women limiting their consumption of fish like tuna, swordfish, shark, and other species that feed on the top of food chains.

Yet, as with most environmentally mediated health risks involving either chemical or biological agents, the ecological dimensions and health effects of Hg are far more subtle than either the tragic Minimata case or the health warnings suggest. This was illustrated more recently by pioneering transdisciplinary and participatory research carried out in Brazil to address chronic, low-level mercury exposure. These efforts demonstrated the efficacy of an “ecosystem approach” in revealing how deforestation and farming practices in the Amazon led to subclinical but nonetheless debilitating neurological manifestations. Few environmental health issues demand a transdisciplinary research agenda that spans such a wide range of disciplines – from biogeochemistry and ecosystem ecology to epidemiology and participatory action research – as environmental exposure to methylmercury (MeHg). Also, among the classic environmental health issues involving human and wildlife exposures to persistent and global contaminants (e.g., lead and organochlorides), MeHg remains the least resolved, in terms of both science and policy.

In 1997, the U.S. Environmental Protection Agency (EPA) issued two reports to the U.S. congress on mercury (Hg) and its effects on public health. The first of these reports, the mercury study report to congress, assessed the source and amount of mercury emissions in the United States, the detrimental effects of Hg on humans and wildlife and the feasibility of control technologies. The second report, the utility hazardous air pollutant report to congress, looked specifically at emissions from utility companies and cited Hg as a major contaminant, especially in emissions from coal-fired power plants. Once in the environment, Hg can be converted to MeHg, which bioaccumulates in the food chain. Such bioaccumulation can lead to high concentrations of MeHg in predatory fish. Because of concerns about MeHg exposure levels in the United States from the consumption of contaminated fish, particularly among sensitive populations, questions have arisen among federal agencies over what is an acceptable level of exposure to MeHg. Because of gaps in the scientific data regarding Hg toxicity, particularly MeHg, the potentially widespread implications from human health, and the high financial costs and feasibility problems associated with further regulating Hg emissions, Congress directed EPA in the House Appropriations Report for EPA'S Fiscal 1999 funding to contract with the national research council (NRC) to prepare recommendations on the appropriate reference dose for Hg exposure.

International conference on Mercury as a global pollutant (ICMGP) provides a needed global forum for the exchange of innovative ideas, and it provides an opportunity to communicate research results to public policy makers, industry experts and public representatives in order to promote the direct use of scientific and technical data to environmental protection and control. Intense interest in mercury is evident from the recommendations adopted by the European Union Mercury Strategy in June 2005; also, a Global Mercury Assessment was approved by the governing council of the United Nations environmental program in early 2002. The 7th ICMGP was held in Ljubljana Slovenia, the location of the second largest mercury mine in the world – the Idrija mercury mine. Although the mercury mine was the

basis of prosperity of the town of Idrija for five centuries, it also caused extensive contamination of the town and its surroundings, leading to high levels of mercury exposure of the miners and the other inhabitants. The mercury mine was closed in the mid-1980s to avoid further releases of mercury to the environment. Mercury research in Slovenia was initiated by the Jozef Stefan institute in the early 1960s as a result of environmental and health concerns related to the operation of the mine. Initially, the main goal of the institute was to address the health status of the miners. Studies of the effects of mercury on the environment soon followed, and results have been published widely in the scientific literature.

In the summer of 2006, the “Eighth International Conference on Mercury as a Global Pollutant” was held in Madison, Wisconsin, to which over 1,000 scientists from around the world came to share their understanding of the environmental fate of this pervasive contaminant. The global nature of Hg is due to a number of factors: (1) it is generated largely from coal-fired power plants which are increasing worldwide; (2) it is atmospherically transported from these sources to eventual deposition on all land and water surfaces; and (3) it is transferred to humans through fish consumption which knows no international or socioeconomic boundaries.

Mercury in combination with allergens has a tendency to rupture white blood cells, precipitating allergic reactivity. The connection is made between dental mercury amalgams and chronic fatigue/immune depression syndrome. Mercury crosses the placental barrier to contaminate a developing fetus. Mercury exposure is not something to ignore.

The quicksilver of creativity will not be solidified by legal pronouncement; it will necessarily flow into new and sometimes frightening fields (Mathew Tobriner)

Aligarh, India

Shabnum Nabi



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## Acknowledgements

Real life isn't always going to be perfect or go our way, but the recurring acknowledgement of what is working in our lives can help us not only to survive but surmount our difficulties.

(Sarah Ban Breatnach)

All thanks are due to *Allah* – The creator, cherisher and sustainer of the universe. He created man and “taught him that which he knew not” (Al-Quran). He is most Gracious and most Merciful to all his creations. He endowed me with the requisite knowledge and ability to embark upon this piece of work and bestowed upon me the courage, patience and strength to carry it to its completion. It is indeed a great pleasure to acknowledge my humble sense of gratitude to *Springer* for encouraging me to pen down this work in the form of a book. Their encouragement to young budding authors and researchers for writing manuscripts, monographs and books without any financial implications to the authors is greatly appreciated. I thank my Lord for giving me such polite *Parents* whose adore, forfeits and sustained endeavors enabled me to acquire knowledge. Whatever I am today is the result of their prayers, love, care and sincere efforts. To my extended family, I hardly know from where to begin but here it goes. I sincerely acknowledge the generous help rendered by my elder biological brothers *Mr. Mushtaq Ahmad*, *Mr. Parvez Ahmad* and *Er. Mohammad Lateef*. Words seem to be inadequate for the immense appreciation and gratitude to my brother *Dr. Tariq* who encouraged, helped, tolerated and supported me in all stages of my endeavour and without his active cooperation this book would not have seen the light of day.

I strongly feel that no word of formal acknowledgement can possibly express the help rendered by my supervisors *Dr. Anjum Ara* (Reader, Department of Zoology, AMU, Aligarh) and *Dr. Shamim J. Rizvi* (Director, Interdisciplinary Brain Research Centre, J.N. Medical College, AMU, Aligarh). The support provided by them certainly deserves special mention. I thankfully acknowledge my debt to *Prof. Irfan Ahmad* (Chairman, Department of Zoology, AMU, Aligarh) and *Dr. G.G.H.A. Shadab* (Sr. Assistant Professor, Department of Zoology, AMU, Aligarh) for their continuous encouragement and valuable advice during the preparation of the manuscript.

I recognize the contributions of many of my *learned friends and colleagues* who kindly shared their special knowledge with me and volunteered their intellectual capabilities in shaping this book. Surely, there are too many to name, but finally I would like to dedicate this book to all those who indirectly



provided indispensable support and continuous backup, showered with lots of affection and prayers. Distinctive thanks to them for immensely boosting my morality.

Knowledge is the end based on acknowledgement.

(Ludwig Wittgenstein)

Shabnum Nabi

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## About the Author

Dr. Shabnum has obtained her Ph.D. degree in Zoology (Cytogenetics) in 2012. The prime focus of her research has been neurotoxicity, genotoxicity and neurobehavioral toxicity. She is the author of several papers published in reputed and peer-reviewed journals. Besides having National and International conferences to her credit, she is the member of Zoological Society of India. She has participated as a young scientist in a congregation of Nobel Prize Winners at IIT Allahabad. She has also availed a Research Fellowship (JRF) from University Grants Commission (UGC), New Delhi.

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Part I

History of Mercury Toxicology

