Coastal Hazards • O.P. Varma • G.V. Rajamanickam • Eugene Wilson

IGC (INDIA)

Coastal Hazards

Editors

O.P. Varma G.V. Rajamanickam Eugene Wilson

Indian Geological Congress

Coastal Hazards: An IGC (India) Publication

Editors

O.P. Varma G.V. Rajamanickam Eugene Wilson

O.P. Varma is an accomplished geoscientist, deeply motivated to serve the cause of geosciences and IGC (India) to grow as a world-class scientific association. He has been its Hony. Editor for over two-and-a-half decades, besides being its President for the years, 1998 & 1999, and since its formation as a Society, promoter of its growth and development with extraordinary passion. To his credit, there are several thematic volumes and innumerable scientific contributions.

Dedicated for over four decades to teaching, research, and development programmes in the area of ore geology and its allied branches, with Ph.D. in Mining Geology and DIC from Imperial College, London, Prof. Varma has spent almost his entire professional career as Professor of Mining Geology in the Department of Applied Geology, Indian School of Mines, Dhanbad, where he founded mining geology lab. and three new M.Tech. courses, including mineral exploration course, first time in India. He is the Past President of Earth System Sciences Section of the Indian Science Congress Association and also of the Indian Geological Congress. He is recipient of several awards, including those of NSF (U.S.A.), U.S.S.R. Academy of Sciences, Chinese Academy of Sciences, and others. Teaching has been his forte and his accomplishments in the profession of teaching and research have been recognised by the UGC in the Award of National Lecturer in Mining Geology and Distinguished Academic Service Award from ISM (1986), and also Basant Samman (1987). He is a very widely-traveled person on a number of academic assignments.

He also served on the Editorial Commission of "Geotectonic et Metallogenia", published by the Institute of Geotectonic at Changsha, China.

G.V. Rajamanickam is presently Director (Research) in Sri Sairam Group of Institutions, Tambaram, Chennai. Previously in SASTRA University, Thanjavur, he was the Dean and the Founder of the Centre for Advanced Research in the Indian System of Medicine (CARISM); there he also served as Head & Professor of the Department of Disaster Management.

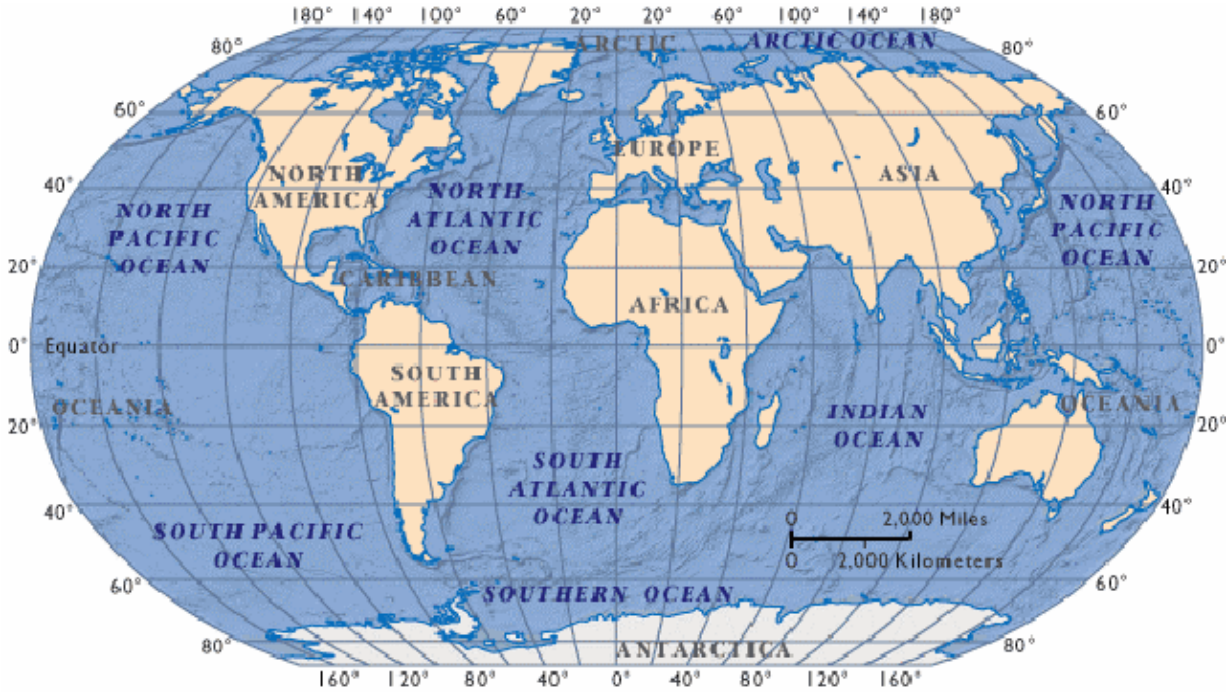
Prof. Rajamanickam began his professional career in the National Institute of Oceanography, Goa, and thereafter, he shifted to Tamil University, Thanjavur, as Professor and Head, Department of Earth Sciences. He is one of the pioneering geologists in India in the field of coastal studies and marine mineral exploration; he led the country's first historical cruise for manganese-nodule exploration in the Central Indian Ocean basin. He had been the Visiting Professor in St. Andrews University, Scotland and R.W. Technische Hochschule Aachen, Germany. He has published more than 250 research papers and articles, authored and edited more than 10 books, besides having supervised as many as 35 Ph.Ds.

Eugene Wilson is currently working in the National Institute of Indian Medical heritage, Hyderabad. Earlier, he served as Senior Lecturer in SASTRA University, Thanjavur, for over 5 years. There he provided commendable support to the establishment of the Centre for Advanced Research in the Indian System of Medicine (CARISM) at SASTRA.

He is a recipient of the 7th European Union Research Fellowship on "Preventive Medicine and Age in Traditional Indian Medicine" at the Department of Complementary & Integrative Medicine, University of Duisburg-Essen (UDE), Germany, for a year, which he later visited thrice as a guest-scientist on the invitation from the UDE. Apart from being a proficient teacher, Dr. Wilson is a devoted & dedicated researcher in the area of Siddha medicine. He has published a good number of papers in this area. Because of his singular expertise in the field of Siddha medicine and medical geology, he distinguished himself as an invited speaker to deliver the 13th Professor Jhingran Memorial Lecture on the subject of Siddha System of medicine under the aegis of Indian Geological Congress.

The Great Oceans

(Source: *http://go.hrw.com/atlas/norm_htm/oceans.htm*)



Planet Earth

Surface Area of the Planet (510,066,000 sq km)
Land Area on the Planet (148,647,000 sq km) **29.1%**
Ocean Area (335,258,000 sq km)
Total Water Area (361,419,000 sq km) **70.9%**
Type of Water (97% salt), (3% fresh)

To convert sq km (kilometers) to sq miles, multiply kilometers by: 0.386102

Oceans by size

1 **Pacific** (155,557,000 sq km)
2 **Atlantic** (76,762,000 sq km)
3 **Indian** (68,556,000 sq km)
4 **Southern** (20,327,000 sq km)
5 **Arctic** (14,056,000 sq km)

Greatest depths in the oceans

Mariana Trench, Pacific 35,827 ft
Puerto Rico Trench, Atlantic 30,246 ft
Java Trench, Indian 24,460 ft
Arctic Basin, Arctic 18,456 ft
Southern Ocean, (greatest depth in dispute)

Deepest Oceans and Seas

1 **Pacific Ocean** (35,837 ft) (10,924 meters)
2 **Atlantic Ocean** (30,246 ft) (9,219 meters)
3 **Indian Ocean** (24,460 ft) (7,455 meters)
4 **Caribbean Sea** (22,788 ft) (6,946 meters)
5 **Arctic Ocean** (18,456 ft) (5,625 meters)
6 **South China Sea** (16,456 ft) (5,016 meters)
7 **Bering Sea** (15,659 ft) (4,773 meters)
8 **Mediterranean Sea** (15,197 ft) (4,632 meters)
9 **Gulf of Mexico** (12,425 ft) (3,787 meters)
10 **Japan Sea** (12,276 ft) (3,742 meters)

*Note that official depths for the **Southern Ocean** are still disputed. Current measurements indicate its greatest depth to be (23,737 ft) (7,236 meters). That would make it the third deepest body of water on the planet.*

(Source: *http://www.worldatlas.com/aatlas/infopage/oceans.htm*)

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Indian Geological Congress
Roorkee-247 667 (INDIA)

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Published by : INDIAN GEOLOGICAL CONGRESS
Roorkee - 247 667 (India)

Phone : 01332 - 277827 / 09219414329
Fax : 01332 - 277827
Email : *igcroorkee@ymail.com / igcroorkee@gmail.com*
Website: www.igcindia.net

First Printing: August, 2010

Price: □2000.00 Hard Bound (*In India*)
U.S. $ 200.00 Hard Bound (*Abroad*)

Technical Supervision and Type Setting by: *Anita Singh,* Assistant Editor
Indian Geological Congress
Roorkee - 247 667.

Printed & Bound at : *M/s Anubhav Printers,* 15, Civil Lines, New Haridwar Road,
Roorkee - 247 667 **(Uttarakhand).**
Tel : 01332-271237 / 9719004321

COVER-PAGE: *The furious tsunami waves dashing to the Chennai Coast* (Courtesy: **Eugene Wilson).**

FOREWORD

The oceans constitute a great challenge and opportunity for man and in many ways they are unknown and mysterious. There are myriads of values of oceans to man – scientific, military, economic, political and recreational. At the same time, oceans hazards destroy human life and its property, natural ecosystems and modify geomorphology. The development of petroleum and allied industries has encouraged migration of population to coastal areas leading to deterioration of coastal environment. The coastal populations, the industry, the infrastructure and other ancillary units have, therefore, become highly vulnerable to ocean-related hazards on an unprecedented scale.

I am glad to note that the Indian Geological Congress in association with the Department of Disaster Management, SASTRA, Thanjavur, had organized the first International Conference on "Coastal Hazards", from February 9 to 11, 2005, and brought out brochure of recommendations as emerged from the Conference, and now the thematic volume on "Coastal Hazards". The subject of coastal hazards is highly relevant to India as it has a long coastline of 7500 km. The Indian coast is prone to cyclones, storm surges and sea-level rise. The great tsunami, the most destructive waves struck on Indian coast and the Andaman and Nicobar Islands on 26th December, 2004, leaving several thousands of people dead, besides inflicting tremendous loss of properties and infrastructure. I hail the efforts of the organizers to have conducted a debate and discussion on the tsunami.

To prepare an integrated and comprehensive multi-hazard system for prediction, advance warning, timely-evacuation, protection of human life and property, and other measures, including post-disaster relief and rehabilitation, it is necessary to collect wide range of information as possible. I hope that this volume will fill up the knowledge gap and serve as a potent data-base on coastal disasters for various agencies.

I greatly appreciate the efforts of Prof. O.P. Varma, the Chief Editor, and his team members for their untiring efforts to publish this volume.

(Shailesh Nayak)
Secretary

PREFACE

Hundreds of million of people of coastal region world over depend on safe and hospitable marine environment for food, shelter, livelihood and for cultural fulfillment, but disasters – both natural and man-made - threaten life, property, sea-food and infrastructure. Problems related to pre-, during, and post-disaster scenario are, therefore, to be identified, tackled and remedial measures adopted speedily; daunting task at first sight, but – has to be accomplished by sharing knowledge of all concerned.

Surface of the globe is about 510 million sq km. Of this, oceans cover more than 70 per cent of the Earth's surface, the rest is held by the continents. The ocean floors and the continental masses have profoundly different geological compositions. Around the margins of the land-masses is a platform of varying width and is covered by no great depth of water; it is geologically related to the continents and accordingly called the continental shelf. Adding its area to that of the landmass, we shall obtain a figure of 35 per cent for the continental surface. The topographical extremes of height and depth are respectively 8840 m at the Everest on the continent, and 11,520 m in the Mariana trench, off New Guinea. Investigations have revealed that there is really scarcity of high mountains and deep seas. Such features are found to be linear in form, & to them we designate as mountain belts & oceanic trenches respectively.

Oceanic geology has turned out to be much simpler than the geology of the continents. New ocean bottom is continuously being extruded along the crest of a worldwide system of ridges, which are offset by fracture zones. Earthquakes occur along the crests of ridges on parts of the fracture zones, and along deep trenches, where the ocean-floor dips steeply.

Oceans contain some of the Earth's most complex ecosystems. Apart from serving as habitat for a vast array of plants and animals, the oceans supply food, energy and mineral resources for our life-sustaining needs. The coastal zone constitutes only about 10 per cent of the total oceanic area, but accounts for more than half of the ocean's biological productivity and bears almost the whole impact of any disaster, generated in the ocean-region such as hurricanes, cyclones, tsunamis, storm surges, tidal waves, tropical storms, etc. Coast yields nearly all the world's catch of fish. As a result of such diversified life-support activities, coastal areas contain many kinds of ecosystems that are vital to marine life and human population.

About 60 per cent of the world's population, or nearly 3 billion people, live on or within some 100 km of the sea-coast. India has approximately 7500 km coastline, including the islands. And, along the coastlines of Bangladesh, India, Pakistan, and Sri Lanka, population densities often reach up to 500 per sq km, representing more than the number of the people living in the interior. But – coastal areas are the most vulnerable to hazards and also the most abused zones of the oceans by anthropogenic activities, being devastated, time and again, by weather-related disasters. Although successfully prognosticated, the destruction inflicted by them to property and personal belongings of the people is not yet fully eliminated, because of large population, poor quality of infrastructure and slow rate of evacuation during disasters.

The trends of the last 30 years show increasing intensity in coastal pollution, accelerated destruction of coastal marine habitats, and in many areas, a declining catch of marine fish species due to pollution growth, over-fishing, and high rate of exploitation of marine mineral resources. All and sundry create human health problems and other kinds of coastal and marine

degradations appertaining to physical, chemical, biological changes, coastal erosion, beach pollution and shoreline damage by waves, tides, near-shore currents and man-made engineering and building structures, municipal sewages and habitat destruction, especially of wetlands, mangroves, salt marshes and sea-grasses, which are being rapidly slenderized for urban, industrial, and recreational growth and development of aquaculture. Protection of environment from pollution, therefore, should be mandatory for human-kind sustainability.

Many factors are responsible for the large-scale and unchecked pollution, including poor drainage discharge system, contamination from ships, increasing population pressure, unsystematically planned developmental and industrial structures, introduction of petroleum into the marine environments along with the ones due to oil-spills, ship-wreckages, dumping of nuclear wastes and other mishaps. Aside from these factors, both see-page and agricultural runoff introduce large quantities of nitrogen and phosphorus into coastal waters. Their compounds nourish algae and can deplete the water of oxygen and suffocate other species. Oxygen-depleted waters are known as "dead zones", which can block sunlight and stunt growth of other marine life.

The International Conference on "Coastal Hazards", was organized by the Department of Disaster Management, SASTRA University, Thanjavur, jointly with the Indian Geological Congress, from February 9-11, 2005. It has been the maiden event on the theme on "Coastal Hazards" ever held in India. More than 100 participants, including one each from Sri Lanka and Bangladesh attended the programme. Nearly 50 papers plus two poster presentations and ten keynote addresses were delivered. The Conference was sponsored by 15 government and public and private sector industries, including DST, DOD and ONGC, in particular. All and sundry, however, very much missed the presence of Shri Subir Raha (who is no more with us in this mortal world), President IGC and the Chief Guest of the Inaugural Function due to his sudden indisposition. However, in his absence the Conference was inaugurated by Dr. S. Asokan, Chief Executive, Titania Business, TATA Steel.

The conference focussed on man-made coastal & marine pollution, and natural hazards – cyclone, tornado, hurricane, storm, king-tide, tidal surge, sea-wave, sea-erosion, sea-level oscillation, cliff slumping, coastal inundation, sea-water ingression, depletion of coastal aquifers, etc., and aimed at establishing such measures, which could help reduction of occurrences, and minimization of adverse impacts of these hazards, appreciating that any progress of local, regional, national, or global sustainable development, in the larger context, would be a misnomer without having deep insight into the methods of protection, proper risk assessment, and efficient management. The conference brought out concrete recommendations for coordination of efforts among various government departments and specialized agencies in order to help damage reduction and improve relief measures, especially during post-disaster operations. Currently, disaster control and mitigation measures are on the concurrent list of education and research; so is *"disaster management"*, a frontrunner issue among other contemporary issues. Since both national and international disaster management policies and programmes need to be complementary, the conference also notably attended to international level problems to seek international involvement.

Role of education, mass-media, training were given due emphasis. Due weightage was also given to prevention and prediction of disasters. Suggestions were put forward to the solutions

of problems, like re-settlement, rehabilitation, relief-management, disaster control, disaster mitigation, institutional frame-work and international cooperation.

Deliberations also focussed on comprehensive legislation policy for implementing various international and national measures, regarding prevention and control of marine pollution. Are earlier legislations enough or do we need more comprehensive legislation, covering wider and more inclusive aspects? – the Conference did spell out its views on this issue as well. Measures, such as collection of CESS, imposition of fines and penalties against coastal degradation and pollution, were addressed by the Conference as matters of concernment.

Tragically on the 26th December, 2004, the tsunami, all of a sudden, struck the south-east Asian Countries, which had claimed a toll of more than 1.6 million people living in the coastal region of the affected countries, including nearly 18,000 human lives in India, the worst being Car-Nicobar, where more than 10,000 people were estimated to have died. To bring out concrete suggestions & recommendations on the unprecedented catastrophe organizers set aside one full day for discussions on major technological and other issues, related to the tsunami. In this session, nearly twenty papers on various aspects of tsunamis were debated in-depth. Scientific presentations and analytical results, related to tsunami aspects have, first time, been brought out at the Conference with the emergence of a large number of recommendations made unanimously.

The conference observed that we, as earth scientists & technologists and management personnel, including doctors & engineers, have a big role to play by sharing knowledge for minimizing losses by such a monstrous calamity, if again struck by such disasters in future, through developing prediction devices and warning signal systems, besides creating relief management cadre of efficient, honest, dedicated, well-trained volunteers, devoid of disdained & egoistic officialdom.

Earlier in the Plenary Session, preceding the Concluding Session, the delegates desired that the Chairman, Organizing Committee, Prof. O.P. Varma, to take expedient follow-up action on the recommendations. In keeping with the wishes of the delegates these were brought out in a separate brochure and circulated widely among various agencies, NGOs and government departments.

This International Conference concluded its deliberations in the afternoon of the 11th February after Valedictory Function with Prof. D. Jayakumar, Former Vice-Chancellor, Periyar University, as Chief Guest in the Chair. The Session was presided by Prof. S. Vaidyasubramanian, Dean (Planning and Development) of SASTRA. Broad spectrum of recommendations made by the Conference under various heads is given in Appendix I.

This special volume on "*Coastal Hazards*", containing twenty-four papers, is divided into five
sections, sequentially arranged on the discussed topics of Tsunamis, Cyclone and Storm Surge, Coastal Erosion and Environment Degradation, Urbanization, and Coastal Ground Water Management, and Mitigation of Hazards.

In planning, programme-evolution, and organisation of the Conference, the organising committee received whole-hearted support from the authorities of SASTRA University, including that from Prof. R. Sethuraman, Vice Chancellor; Prof. S. Vaidyasubramanian, Dean

(Planning & Development); and Prof. C. Swaminathan, Dean (Sponsored Research). I, as Chairman of the Organizing Committee, must place on record sincere gratitudes to them for the support provided for the organization of the Conference. The organizers are also thankful to the staff-members and the students of the Department of Disaster Management, and the Centre for Advanced Research in Indian System of Medicine (CARISM), SASTRA University, for the help given towards organization of various activities of the conference. We, among others, owe grateful thanks to ONGC, and other sponsors for the generous financial aids without which the conference programmes wouldn't have come out so successfully. Their names have already been highlighted in the Abstract Volume prominently.

The Assistant Editor Anita Singh deserves special thanks for her constant and repeated concern for the growing delays in the publication of the volume. She also very readily formatted the entire manuscript, while other staff members of the IGC secretariat did various other jobs related to the publication work gladly and unhesitatingly. Special appreciations are expressed for the entire team of workers of the IGC for the help I received from them at various times.

Thanks are also expressed to contributors of the papers without which this publication wouldn't have been possible. I would like finally to thank the Ministry of Earth Sciences, Govt. of India, for adequate grant-in-aid towards the publication of this very special volume. Lastly the editors must give expression of sincere regrets for delay in printing of this volume, which has been primarily due to the long time taken by the contributors and the referees. Hopefully, the sharing of knowledge in this volume will help all of us in seeing a safer and better future.

Indian Geological Congress **O.P. Varma**
August, 2010 **(Editor)**

Better is one's own duty, although imperfect than that of another well performed.
He who does the duty born of his own nature incurs no sin.

*— **Bhagvad Gita,**(18.15-48)*

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