

VEERAVALLI VENKATA RANGA VARADACHARI

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VEERAVALLI VENKATA RANGA VARADACHARI
(1925-2007)

Elected Fellow 1981

VEEERAVALLI VENKATA RANGA VARADACHARI, popularly known as VVR amongst the colleagues and oceanographer community, will be remembered for his honesty, sincerity and for his soft approach in solving critical, difficult and delicate managerial matters within public and private domains.

A non-interfering type, VVR commanded respect and shouldered responsibilities to develop the most exciting subject of physical oceanography in India with patience and insight. He was a person with a high sense of discipline and integrity and worked towards the overall growth of the science of oceanography at national level - National Institute of Oceanography (NIO) - and he never spoke ill or disparagingly of others.

While discharging the official duties, VVR neither directly nor indirectly promoted the idea of permitting junior, less experienced members of the organisation or fresh job seekers to supersede an incumbent employee. In a way, he was a true believer and executioner of the book of rules and preferred always to take the path of least resistance whenever such situations arose.

His honesty and integrity was unquestionable, whether in managerial work, or bringing out research results either for publication or to help needy researchers. He never showed any sort of urgency or eagerness to have the results of research or administrative decisions without being satisfied to the best of his knowledge.

All his pupils remember him with gratitude, affection and respect as an unforgettable character who laid stress on the need for comprehensive (*sampurna*) knowledge in basic mathematics and moulding them into decent, dignified human beings. Thus, the exposure-shy, never-in-a-hurry VVR occupied a special place as a teacher to quite a few, supervisor to some, and a friend and philosopher to many, in addition to a non-practicing experimentalist and a follower of the philosophy of homeopathic medicine.

The extent of the involvement of VVR in the multi-disciplinary research activities concerning physical oceanography individually and in collaboration with his research students and associates at the institutional level could be assessed from the review study made in 1987 and documented in 'Oceans and the Indian Summer Monsoon'. *Biographical Memoirs* 62

FAMILY BACKGROUND

VVR, the eldest of three children, was born in an orthodox family, to Shri Appan Singarachari and Smt. Kanakamma, on July 1, 1925, at Gutala village on the banks of river Godavari, in Andhra Pradesh. He was married to Kum. Kamala and the couple had four daughters and two sons – all gems of academic brilliance without any exception. He breathed his last on August 4, 2007, at the residence of his youngest child - Ms. Padma Parthasarathy - at Bangalore.

EDUCATION

VVR completed his elementary, primary and secondary education in the rural and semi-urban environs prevailing during those times in Andhra Pradesh.

After a year's service with the Government's Department of Defence Accounts at Jabalpur, to meet the finances required for higher studies, VVR got himself enrolled as a student at the Andhra University's College of Science and Technology at Waltair and went on to receive BSc (Hons.) degree in Physics with top rank, in 1948. For VVR, who was interested in pursuing an academic career, obtaining this rank at the graduate level from the physics faculty headed by a renowned physicist, Professor Suri Bhagawantham (who later retired as Scientific Advisor in the Prime Minister's Office, Government of India) was really a big step in a forward direction.

Later, at the suggestion and advice of the then Principal of the Andhra University Colleges of Science, Professor C Mahadevan, VVR took admission as a post-graduate student in the newly started science faculty of Meteorology and Oceanography under the Geophysics group and won accolades by receiving the degree with a First Class, in the year 1949.

Later, on a Government of India Fellowship, VVR proceeded to do an advanced course in fluid dynamics from the Dept of Meteorology. This was then an US Air Force Advanced Training Centre in meteorological forecasting, at the Florida State University, Tallahassee, USA. He obtained MS degree, in the year 1956. Studying under the guidance of Professor Seymour L Hess at this University, he obtained 'A' grades in advanced physical oceanography, hydrodynamics and several other subjects – a real big test to prove his ability and preparedness to meet the requirements of higher understanding and sound knowledge in advanced mathematics. He always used to emphasise the point: to be successful in science disciplines, one should be sufficiently equipped and reasonably proficient in mathematics apart from putting in hard work. He used to help with pleasure and ease many a researchers approaching him with doubts or seeking support in solving mathematical sections or equations.

He received the DSc degree in (Geophysics - Oceanography) from the Andhra University in the year 1959 for the doctoral dissertation titled "On some *Veeravalli*

Venkata Ranga Varadachari 63 meteorological and oceanographical studies of the coastal waters off Waltair in relation to upwelling and sinking" submitted in 1958. In this study, to explain the movement of the waters in the vertical and in the horizontal planes from an analysis of the thermal structure of the waters off the central east coast of India; he applied the well-known Bjerknes' circulation theorem and reported the dominance of the flow field over the wind stress distribution. This was adjudged as critical for consideration of the findings and for the award of the doctoral degree by the members of the board of adjudicators – Sir George Deacon from UK, Professor Walter H Munk from USA – for the dissertation submitted in geophysics.

PROFESSIONAL CAREER

VVR had an in-born passion towards teaching. According to his own confession, he used to share knowledge acquired with his friends and at times provide tuitions to colleagues and students of secondary schools, before himself getting qualified with the first stage of secondary school education – a Secondary School Leaving Certificate.

VVR joined the staff of the Faculty of Meteorology and Oceanography in the year 1949 and could rise only to a lecturer status in 1956 (a scenario very common in those times, believably with the authorities following strictly the school master's philosophy) – a position he occupied at this venue till 1962.

The alumni of this faculty from the Andhra University who shared knowledge and trained under the guidance of VVR, either as immediate juniors and continued to carry out research and/or pursued academic careers in United States of America, Canada include Prof. TN Krishna Murti (NOAA); Dr P Krishna Rao (ESSA); Prof. TS Murty (Canada); Dr DB Rao (NOAA); Dr C Prabhakara. A good number of students received expert suggestions and guidance for their doctoral dissertation work in India and made significant progress in research and in teaching faculties. These include Dr C Balarama Murty (Defence R&D, GOI); Prof. GS Sharma (ex-Cochin Univ.); Prof. PG Kurup and Mr. B Rami Reddy (Cochin Univ.) Prof. MPM Reddy and Prof. V Hariharan (Fisheries College, Mangalore); Prof. Debasis Sengupta (Indian Institute of Science), to name a few.

During 1956-1962, VVR's research activity centred on investigations associated with the circulation of the waters of the seas bordering India. He took part in the collection of data relevant to the physical oceanography of the waters bordering the coast of India, on board the Indian Naval Vessels and improvised boats together with the visiting researcher Mr Eugene C LaFond, from the US Navy Electronics Laboratory, San Diego, California, USA. The efforts put into the field studies resulted in developing a new theory that laid importance on the role of coastal current as a primary candidate to address upwelling events along the coasts. This

theory has been found to be useful in explaining the welling features of the waters of *Biographical Memoirs* 64 the upper layers along the Indian coastline – an approved successful theory to explain the upwelling aspects along the Somali coast according to Professor Henry Stommel, a highly revered ocean researcher in Physical Oceanography, and a core member, founder and co-promoter of the International Indian Ocean Expedition (IIOE).

The next most promising study that demands listing to the accredited theoretical investigations by VVR is the extension of investigation into the divergence and convergence processes towards the open ocean environment – pursued through a post-graduate student. This study relates to surface water circulation in the northern Indian Ocean and is the start of micro-level team work. The investigators utilised the isogon method of analysis (adopted usually by synoptic meteorologists involved in the preparation of weather charts to understand and forecast the wind field – a tool towards detailed wind field analysis) to the climatological, ocean surface currents. An isogon is a line passing through the points having same (constant) direction of flow. Stress is laid on the cartographic representation of various physical oceanographic and meteorological features in the absence of adequate physical and chemical oceanographic data to locate areas of divergence and convergence of utmost importance to the biological productivity of the ocean. This study was nearly complete before VVR relinquished the duties as Lecturer at the Andhra University in September 1962.

VVR joined the National Geophysical Research Institute (NGRI) at Hyderabad in September 1962 and shortly thereafter moved to Cochin as Senior Scientist with the Oceanographic Research Wing (ORW) of NGRI. His duties covered a wide range starting from management to the organisation of research well beyond the fundamental- or application-oriented basic research for the up-coming oceanographic research in the country. He was one of the foremost Indian Oceanographers to take part in the International Indian Ocean Expedition (IIOE) during 1961-65, apart from Dr JS Sastry, Dr AA Rama Sastry, Dr D Srinivasan, Dr C Balarama Murty, etc. On official completion of IIOE schedule, the member-secretary to the Indian National Committee on Oceanic Research (INCOR) in India, Dr N Keshav Panikkar, got the ORW administration transferred from NGRI and made ORW the nucleus for the creation of National Institute of Oceanography (NIO) on 1st January 1966 under the structural canopy of Council of Scientific & Industrial Research (CSIR). VVR, later shifted the place of research work from the Indian Ocean Physical Oceanographic Centre (IOPOC), Cochin to NIO, Goa in the year 1969 and continued to serve the organization with utmost devotion till his retirement in July 1985.

After taking up duties with the CSIR during later half of 1962, in the Physical Oceanography discipline, and in the absence of a sea going research vessel, VVR

opted to carry out research on factors contributing to large-scale erosion/accretion of the beaches along the coasts of Kerala. During this intervening time, he had to share the duties of administration with the Director of the Institute - which was in the infant stages of growth from all quarters, especially in the much needed and most important matters concerning acquisition of a sea going vessel (after a tumultuous struggle, a hopper barge was located and finally procured to be christened RV Gaveshani later) and its conversion to suit operation towards ocean research. VVR took a keen interest in getting the scientist community joining the NIO to take part in the scientific cruises on board INS Darshak, a research survey vessel belonging to the Indian Navy. More time, therefore, was needed to be spent on features for structuring and enabling on-the-site-research component with little or no time to consolidate the results of the ongoing coastal and near-shore studies. In continuation with these, he got involved in several site-specific, ocean environment related investigations for over a decade. These are meant for discharge of industrial, domestic waste products from industries and city complexes along the coasts of India. He undertook systematic, detailed oceanographic surveys of the waters of the northern Indian Ocean to address problems related to ocean-atmosphere interaction (especially the vagaries associated with the southwest monsoon) after the commissioning of Institute's Oceanographic Research Vessel "RV Gaveshani" during 1976.

These surveys attempted

to identify different water-masses of Red Sea and Persian Gulf origin in the Bay of Bengal;

to understand the dynamics of the south-west monsoon through studies of the thermal structure in the Arabian Sea;

to locate several submarine canyons off the shores of Pondicherry, Cuddalore and Palar, analysing the sea bottom topography off the western Bay of Bengal;

Later, VVR investigated at length and in great detail, the transient changes the shoreline along the west coast of India has been experiencing:

to understand the evolution of beach deposits in response to waves, winds, tides; he examined the nature of littoral currents and marked at several locations the presence of dangerous rip currents along select locations of beaches of tourist dominance;

to assess qualitatively the shoreline erosion with reference to the reported/ shifting effects of mud banks along the shores of the coast of Kerala;

to examine and investigate sedimentation events in harbours;

to identify the causative factors for the formation of shoals/bars in the vicinity of river mouths;

to make detailed in-depth studies for dispersal of effluents from the shore based industries/city corporations to advise the local/concerned administrative operators on the plausible after-effects of dumping industrial wastes/water laden with domestic sewage.

These exercises have been executed successfully with the capabilities developed and foundations built during the major oceanographic surveys in the Bay of Bengal and the Arabian Sea as part of IIOE and later as national level contributions to the understanding of the oceanic changes from living, non-living, climate and environment points of view.

Many of the researchers could fruitfully utilise the additions made to the infrastructure facilities from time-to-time to study the acoustic properties of the waters of the Indian Ocean at VVR's initiative and support. The studies helped them to understand the various oceanic processes through use of low frequency sound waves. The data from these acoustic scans of the oceanic interior complemented the information gathered through use of sensors located on board the satellites augmenting and updating the output from large scale numerical models looking at or examining the multi-layered ocean circulation on global scales.

SCIENTIFIC CONTRIBUTIONS

Since 1949, VVR made significant contributions to teaching, planning and organizing oceanographic cruises in the seas around India and formulation of marine science programmes in several Indian universities having postgraduate courses in physical oceanography. He was a pathfinder to the young, aspiring oceanographers in the country during the late fifties and contributed largely to the discipline-wise developmental activity (geological oceanography, marine instrumentation, and ocean engineering, in addition to broadening the scope of physical oceanography to include studies under air-sea interaction). He elevated the status of the Institute to rank amongst the international oceanographic institutions by way of getting recognition, encouraging collaboration at International level in research studies and bringing in programmes involving exchange of researcher(s) amongst various nations, on short- and long-term basis.

A good number of students, seeking advice and guidance from VVR to complete the research work for the award of Ph.D. degree, have gone on to make successful careers of their choice. VVR believed in encouraging the young researcher to be wholly involved from the stage of identifying the scientific aspects requiring explanation/enlightenment to implementing plausible methods to investigating, analysing, interpreting and presenting the notable results independently without getting habituated to spoon feeding. One of the pupils who joined VVR during the later phase of his research career quotes "I was new to oceanography and considered physical oceanography as a bizarre subject which consisted of sinking thermometers

in the ocean and other such meaningless activity. He (VVR) tried to explain the necessity for observations and simple theoretical concepts with patience and insight and was very tolerant of my many foibles and strange activities as a student. He was a scholar and a gentleman and inquired about my work once in a while, but never admonished or lectured me.”

The Institute’s Research Vessel “RV Gaveshani” completed over 100 scientific cruises and has been the main rendezvous for the hydrographic and exploratory bathymetric and seismic surveys in addition to collection of poly-metallic nodules (PMN) for the first time from the Central Indian Ocean Basin. Subsequently, NIO received the status of ‘Pioneer investor’ in the PMN survey in the Indian Ocean.

Under the stewardship of VVR, the Institute of Oceanography shouldered another major share of the responsibilities for the organisation and execution of scientific cruises to Antarctica by providing logistic support and enabling participation of large contingent of scientific personnel from different disciplines from NIO during 1981-84.

AWARDS AND HONOURS

VVR has been a Fellow of all the three major science academies in India. He was a Founder Fellow of the Indian Geophysical Union. He served as a Member-Secretary of the Indian National Committee for the International Scientific Committee on Oceanic Research (SCOR). He has been the Vice-Chairman of the joint SCOR - Intergovernmental Oceanographic Commission’s (IOC) Committee on Climate Changes and the Ocean (CCCCO). He contributed to the preparation of the document “Ocean Sciences for the year 2000” published by IOC, UNESCO.

For the fundamental and baseline work carried out in the formative stages of research in oceanography at national level, and recognising the organisational abilities of VVR, Rani Durgavathi Viswavidyalaya (University of Jabalpur) honoured him with an honorary degree of Doctor of Science in the year 1981.

EXTRA CURRICULAR ACTIVITIES

As a foreign student at the Florida State University, Tallahassee, VVR used to take part in academic quiz programmes. He utilized the little leisure available back home, while in service, to practice Homeopathic medicine and help/advise a good number of people suffering from chronic problems. One patient (who lives abroad, name withheld here for anonymity) was so pleased with the results after following the course of treatment suggested to her that she offered a laptop computer as gift that was politely turned down by VVR as expected. *Biographical Memoirs* 68

LAST DAYS

VVR, though physically not super-active, was active enough till the last day even after undergoing two major surgical operations over a gap of three decades. He used to spend time going through literature on Homeopathy - ailments and cures - apart from enjoying the company and sharing the thoughts of brilliant children and exciting grand children. A cute observation from VVR relates to the thought waves injected to the young brains starting from the juvenile stages has been the advancing technologies. He used to appreciate young minds for the quick and fast responses. At times he used to quip that they need to be explained the errors in conclusions arrived at or choices expressed.

ACKNOWLEDGEMENTS

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BIBLIOGRAPHY

- 1956 Thermal structure of upwelling in spring off the coast of Waltair. In: Proceedings of Oceanography Seminar and Symposium at Andhra University *Central Board of Geophysics* May 1-2.
- 1959 (With RAMANADHAM R) Upwelling and sinking in the coastal waters off Waltair on the east coast of India. In: *Proc International Oceanogr Cong* New York August 1-2.
- 1961 On the process of upwelling and sinking on the east coast of India. In: Professor Mahadevan Shatyabdapurti Commemoration volume. Osmania University Press Hyderabad 159-162.
- 1963 Seasonal variation of some physical features of the coastal waters off Waltair. *Defence Sci J* **10(2)** 147-152.
- 1964 (With SHARMA GS) On the vergence field in the North Indian Ocean *Bull Nat Geophys Res Inst* **2(1)** 1-14.
- 1965 (With SUBBA RAJU G) On a method of obtaining the non-astronomical sea-level *Curr Sci* **34(18)** 532.
- 1966 (With DAS PK and HARIHARAN V) Some studies on wave refraction in relation to beach erosion along the Kerala coast. *Proc Indian Acad Sci* **64(3)** 192-202.

- 1967 (With SHARMA GS) Circulation of the surface waters in the north Indian Ocean. *J Indian Geophys Un* **4(2)** 61-73.
- 1968 (With MURTY CS and DAS PK) On the level of least motion and the circulation in the upper layers of the Bay of Bengal. *Bull Natl Inst Sci India* **38** 301-307.
- (With MURTY CS and REDDY CVG) Salinity maxima associated with some sub-surface water masses in the upper layers of the Bay of Bengal. *Bull Natl Inst Sci India* **38** 338-343.
- (With MURTY CS) Upwelling along the east coast of India. *Bull Natl Inst Sci India* **38** 80-86.
- (With NAIR RR and MURTY PSN) Submarine canyons off the Coromandel coast. *Bull Natl Inst Sci India* **38** 457-462.
- (With MURTY PSN and REDDY CVG) Distribution of total phosphorus in the shelf sediments off the west coast of India. *Proc Natl Inst Sci India B* **34(3)** 134-141.
- 1969 (With MURTY PSN and REDDY CVG) Distribution of organic matter in the marine sediments off the west coast of India. *Bull Natl Inst Sci India B* **35(5)** 377-384.
- 1972 (With DAS PK and MURTY CS) Flow characteristics of Combarjua canal connecting Mandovi and Zuari estuaries. *Indian J Mar Sci* **1** 95-102.
- 1973 (With MURTY CS and DAS PK) Circulation in the shallow waters of the shelf region using sea bed drifters. *Indian Geophys Un Seminar Proc Indian Geophys Un Hyderabad* **10** 199-204.
- (With NAIR RR VARMA PU and Pylee A) Studies on the sediment transport in Mopla Bay harbour Cannanore, using fluorescent tracers. *Indian Geophys Un Seminar Proc* **10** 193-197.
- (With REDDY MPM) Sediment movement in relation to wave refraction along the west coast of India. *Indian Geophys Un Seminar Proc* **10** 169-191.
- (With VEERAYYA M and MURTY CS) Effect of artificially dumped material on the configuration of Baina Beach, Goa. *Indian J Mar Sci* **2** 78-83.
- 1974 (With RAO LVG CHERIAN T and VARMA KK) Hydrographical features of the inner shelf waters along the central west coast of India during winter, spring and summer. *Mahasagar Bull Natl Inst Oceanogr* **7** 15-26.
- (With MURTY CS and SANKARANARAYANAN VN) Physical characteristics of the waters and water masses off the west coast of India during late spring. *Indian J Mar Sci* **3** 1974 1-4.
- 1975 (With VEERAYYA M) Depositional environments of coastal sediments of Calangute, Goa. *Sediment Geol* **14** 63-74.
- (With KURUP PG) Flocculation of mud in mud bank at Purakad, Kerala coast. *Indian J Mar Sci* **4** 21-24.
- (With KURUP PG) Hydrography of Purakad mud bank region. *Indian J Mar Sci* **4** 18-20.
- (With MURTY CS and VEERAYYA M) Littoral and rip currents off Calangute beach, Goa. *Indian J Mar Sci* **4** 1-4.
- 1976 (With KURUP PG and JOSEPH PS) Nearshore circulation in the sea off Velsao, Goa. *Mahasagar* **9** 7-10.
- (With RAO LVG, CHERIAN T and VARMA KK) Hydrographic conditions and flow pattern in Cumarjua canal, Goa. *Indian J Mar Sci* **5** 163-168.

- 1976 (With MURTY CS, DAS PK, NAIR RR and VEERAYYA M) Circulation and sedimentation processes in and around the Aguada bar. *Indian J Mar Sci* **5** 9-17.
- 1977 (With VARMA PU) Stability of the coastline from Manakkodam to Thottappally along the Kerala coast. *Proc Indian Acad Sci (A)* **85** 191-198.
- 1978 (With SWAMY GN) Erosion at Colva, Goa. *Mahasagar* **11** 11-20.
- 1979 (With GOUVEIA AD) Coastal and nearshore circulation off Mangalore. *Mahasagar* **12** 175-182.
- 1980 (With MURTY CS) Topographic changes of the beach at Valiathura, Kerala. *Indian J Mar Sci* **9** 1980 31-34.
- (With MURTY CS, VEERAYYA M and SASTRY JS) Beach morphological variations over micro-time scales. *Indian J Mar Sci* **9** 35-44.
- (With MURTY CS and SASTRY JS) Shoreline deformations in relation to shore protection structures along Kerala coast. *Indian J Mar Sci* **9** 77-81.
- (With SOMAYAJULU YK and RAO LVG) Small-scale features of sound velocity structure in the northern Arabian sea during February-May 1974. *Indian J Mar Sci* **9** 141-147.
- 1981 (With SWAMY GN) Stability and safety of Anjuna beach, Goa. *Mahasagar* **14** 97-103.
- (With VEERAYYA M and MURTY CS) Wave refraction and littoral currents off Colva Beach, Goa. *Indian J Mar Sci* **10** 1-9.
- (With VEERAYYA M and MURTY CS) Sediment distribution in the offshore regions of Goa. *Indian J Mar Sci* **10** 332-336.
- (With RAO LVG and RAMESH BABU V) Structure of currents and hydrographic conditions in the western equatorial Indian Ocean during the summer monsoon. In: Monsoon Dynamics (Proc Joint IUTAM/IUGG Symp Monsoon Dynamics Delhi Dec 1977). Ed by Lighthill MJ Cambridge Univ Press Cambridge UK 453-463.
- (With RAMESH BABU V and RAO LVG) Sea temperature variations in the north-eastern Arabian sea in relation to the southwest monsoon. In: Monsoon Dynamics (Proc Joint IUTAM/IUGG Symp Monsoon Dynamics Delhi Dec 1977) Ed by Lighthill MJ Cambridge Univ Press Cambridge UK 481-489.
- 1982 (With MURTY CS and VEERAYYA M) Morphological changes of the beaches of Goa. *Indian J Mar Sci* **11** 35-42.
- (With SATHYENDRANATH S) Light penetration in the coastal waters off Goa. *Indian J Mar Sci* **11** 148-152.
- (With SIDDIQUIE HN and GUJAR AR) Seabed mining – prospects for India. (Seminar on Metallurgy in Ocean Technology 17 April 1982 Indian Inst. of Metals Bombay) 1-3.
- 1983 (With RAMESH BABU V and SATHE PV) Thermal efficiencies and OTEC potentials at some offshore sites along the Indian coast. (Natl Workshop on Energy from the Sea NIO Goa India 15-16 Dec 1980) *Mahasagar* **16**(1) 1-8.
- 1985 (With BAHULAYAN N) Determination of vertical velocities in the equatorial part of the western Indian Ocean. *Indian J Mar Sci* **14** 55-58.
- 1986 (With BAHULAYAN N) Numerical model for wind-driven circulation in the Bay of Bengal. *Indian J Mar Sci* **15** 8-12.

- 1987 (With DAS VK and SENGUPTA D) Oceans and the Indian Summer Monsoon – A review. In: Contributions in Marine Sciences: Dr SZ Qasim Sastyabdapurti felicitation volume Ed by Rao TSS *et al* National Institute of Oceanography Goa India 141-174.
- (With DAS VK) Oceanography in India. In: Forty years of research - a CSIR overview. Council of Scientific and Industrial Research New Delhi 37-62.
- 1989 (With SENGUPTA R and NAIK S) Environmental pollution in coastal areas of India. In: Ecotoxicology and climate Ed by Bourdeau P *et al.* (SCOPE) Wiley 235-246.

Papers to highlight and mark the alarming status to draw attention of civil/state authorities to address/solve to preservation of environment:

- 1968 The importance of oceanographic studies to the problem of beach erosion of Kerala. *Mahasagar* 1(4) 8-10.
- 1972 Beach erosion and sedimentation. *Mahasagar* 5(2) 85-87.

National Reports presenting the activities within the country relating to marine environment for International Union of Geology and Geodesy (IUGG), through Geophysical Research Board of Govt of India.

- 1971 (With PANIKKAR NK and JAYARAMAN R) Research activities in Physical Oceanography, 1967-1970. National report for IUGG/IAPSO, 15th General Assembly, 20pp
- 1975 (With QASIM SZ) Research activities in Physical Oceanography, 1971-1974. National report for IUGG/IAPSO, 16th General Assembly, 31pp
- (With MURTY CS, DAS PK, DESAI BN, JOSANTO V, SABNIS M.M., SARAMMA UP, GEORGE MD, JOSHI SS and SHAIKH AA) Report on the hydrographic survey of the Mahi estuary and the marine environment for disposal of Industrial wastes. NIO, Dona Paula, Goa; India. February, pp 1-41
- 1976 (With QASIM SZ) Physical Oceanography and Marine Geophysics. National report for Progress in Geophysics, 1975, September 1976, 17pp
- (With QASIM SZ) Physical Oceanography and Marine Geophysics. National report for Progress in Geophysics

The following reports examine the state of the sea environment prior to analysing the capacity of waste water load assimilation - the key for or against disposal by shore based corporate bodies/industries.

- 1971 (With MURTY CS and DAS PK) Physical aspects of the hydrographic survey, during September 1970 to July 1971, off Bombay, July 52
(This study highlights the results of the investigations at the request of Bombay Municipal Corporation (BMC) for discharge of domestic sewage from City Corporation of Greater Bombay into the adjoining sea. With the financial grants to be available from the world bank, BMC sought advice from National Institute of Oceanography (NIO), through National Environmental Engineering Research Institute (NEERI, formerly CIPHERI)
- 1975 (With DESAI BN, MURTY CS, JOSANTO V, SABNIS MM and JOSHI SS) Report on the bathymetric and hydrographic survey off Tarapur for laying a submarine pipeline, February 43.
(This investigation is at the request of Atomic Energy Establishment (BARC) to discharge the waste water from the atomic power station at Tarapur into the sea through either a pipeline or dredged canal).

- 1975 (With MURTY CS, DAS PK, DESAI BN, JOSANTO V, SABNIS MM, SARAMMA UP, GEORGE MD, JOSHI SS and SHAIKH AA) Report on the hydrographic survey of the Mahi estuary and the marine environment for disposal of Industrial wastes. NIO, Dona Paula, Goa, India. February 1-41
(This study was made at the request of Government of Gujarat as a part of their baseline data acquisition and implementation of their cumulative waste disposal scheme).
- 1976 (With KURUP PG, JOSEPH PS, GOUVEIA AD, DELANEY G and ANSARI ZA) National Institute of Oceanography. Report on the studies of physical parameters of the shoreline and the adjoining sea at Loliem, Goa. NIO, Dona Paula, Goa; India. 28.
(This investigation forms the baseline/feasibility study in connection with the proposed atomic power plant).
- 1977 (With KURUP PG and GOUVEIA AD). Report on oceanographic studies off Mangalore coast. NIO, Dona Paula, Goa; India 36
(Sponsored by Mangalore Chemicals and Fertilizers Ltd., Mangalore)
- (With RAO TSS, NAYAK BU, RAMA RAJU, VS VARMA PU and SWAMY GN) Environmental studies in relation to the beach erosion at Thumba. NIO, Dona Paula, Goa India. 73.
(Sponsored by Vikram Sarabhai Space Centre, Trivandrum).

Presentations at Symposia/Seminars (Abstracts):

Results of the investigations undertaken in the nearshore reaches and the open ocean environment prior to their publication have been discussed in detail at two different seminars: (1) CSIR/INCOR symposium on Coastal and Near shore Oceanography, Cochin, and (2) NISI/INCOR Symposium on Indian Ocean, New Delhi. The forerunners of these studies are seen in the form of abstracts at:

- 1966 (With MURTY CS and MURTHY PSN) Beach cycles in relation to tide. *IIOE News Letter*, India. 4(2) 3.
- (With VARMA PU) Wave refraction and beach erosion near Thotapally. *IIOE News Letter*, India. 4(2) 5.
- Some physical aspects of beach erosion of Kerala. *IIOE News Letter*, India 4(2) 5.
- (With MURTY C.S.) The December 1965 storm in the Arabian Sea and its effects on some Kerala beaches. *IIOE News Letter*, India. 4(2) 5.
- (With MURTHY PSN, NAIR RR and PYLEE A) Seasonal changes in the characteristics of beach material. *IIOE News Letter*, India 4(2) 9.
- (With MURTY CS) Studies on the currents and sediment transport near Cochin. *IIOE News Letter*, India. 4(2) 9.
- (With NAIR RR and MURTHY PSN) Physical and chemical studies of mud deposits of Vypeen beach. *IIOE News Letter*, India. 4(2) 10.
- Beach profile changes at some selected points on the Kerala coast. *IIOE News Letter*, India. 4(2) 12.
- 1967 (With MURTY CS) Some observations on internal waves in the Bay of Bengal. *IIOE News Letters*, India 4(4) 45.

- 1967 (With MURTY CS and VARMA PU) Some features of the thermocline in the Bay of Bengal. *IIOE News Letter, India*. 4(4) 45-46.

Lectures delivered at different occasions are:

- 1962 (With SHARMA GS) Divergence of the surface waters in the north Indian Ocean with application to the location of upwelling and sinking. Proc. 49th Indian. Sci. Cong. Part - III, Abstract
- 1972 Coastal oceanography and coastal zone management. NIO/CSIR special colloquium; Panaji, May 1972.
- 1974 Coastal dynamics and coastal zone management. Seminar on Coastal Dynamics, Andhra University and Vizag Port Trust, Visakhapatnam, Sept. Proceedings, Abstracts 1.
- 1976 General problems and investigations in India in the field of coastal oceanography. UNESCO seminar on Co-operative Investigations in the North and Central Western Indian Ocean. Nairobi, March 1976; Proceedings Abstracts.
- (With RAO LVG, RAMESH BABU V and FERNANDES AA) Geostrophic circulation in the NW Indian Ocean during the summer monsoon. In: Proceedings of the Symposium on Tropical Monsoons. Pune. 8-10 Sep. 1976. Indian Institute of Tropical Meteorology, Pune, India. 218.
- (With RAO LVG, RAMESH BABU V and FERNANDES AA) Studies on thermal structure of the northwestern Indian Ocean in relation to southwest monsoon over the Indian Peninsula. In: Proceedings of the Symposium on Tropical Monsoons. Pune. 8-10 Sep. 1976. Indian Institute of Tropical Meteorology, Pune, India. 219.

Overall guidance of research activities leading to the award of MSc/ Ph.D. Degrees:

- Studies on divergence of the surface waters in the north Indian Ocean. (The theoretical analysis making use of the climatological wind field over the Indian Ocean, though delayed unduly, was adjudged as one of the best conventional oceanographic presentations. Ph.D. degree was awarded to GS Sharma in the year 1971 by the Andhra University).
- Wave refraction studies in relation to coastal erosion along a part of the Kerala Coast. (One another analysis having utility in the beach erosion/deposition cycles taking place along the beaches was considered for the award of MSc degree by the Kerala University to PU Varma Thirupad in 1971).
- Studies on the physical aspects of the mud banks along the Kerala coast with special reference to the Purakkad mud bank. (A semi-experimental work was awarded a Ph.D. degree by the Cochin University to Mr PG Kurup in 1975).
- Studies on the physical aspects of shoreline dynamics at some selected places along the west coast of India. (A field based study, from the physical oceanography point of view, made over a decade, to document the changes considered significant in the land-sea interaction zone was accepted for the award of Ph.D. by the Kerala University to CS Murty in 1977.)
- Studies on the geological aspects of the beaches of Goa in relation to some meteorological and physical oceanographic factors. (Similar study, examined from the changes in sediments was duly accredited by a Ph.D. by the Andhra University to M Veerayya in 1978).

- 1976 Some physical and chemical studies of the waters of the northern Arabian Sea.
(The hydrographic data, in conjunction with the chemical aspects, of the waters of the Arabian Sea enabled a Ph.D. degree from the Kerala University to VN Sankaranarayanan in 1978).
- Some physical and dynamical aspects of waves in the sea.
(This theoretical investigation was considered for the award of Ph.D. by the University of Bombay to Debasis Sengupta in 1984).