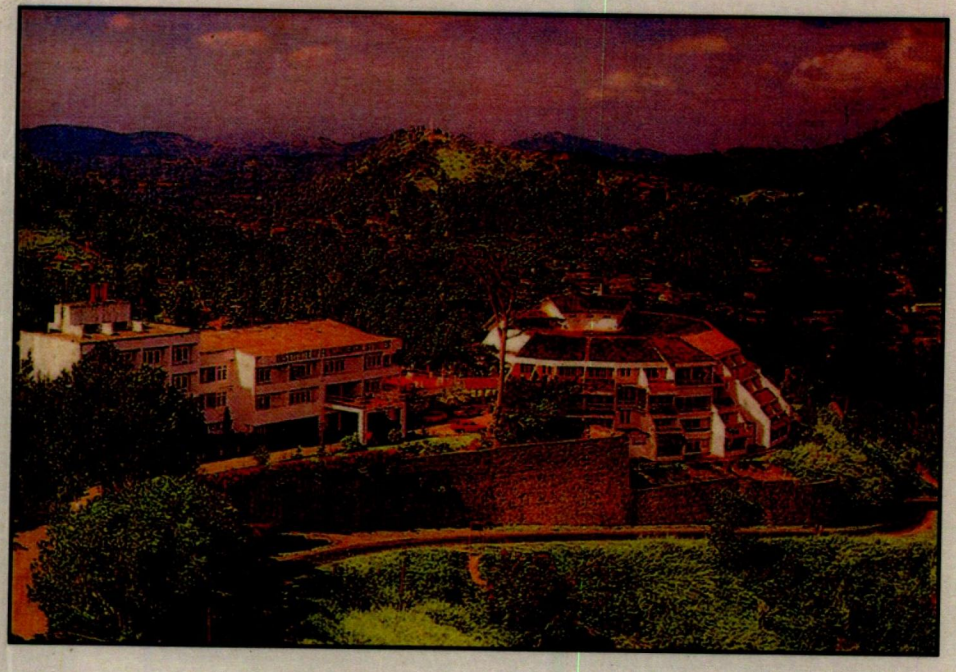
ANNUAL RESEARCH REPORT

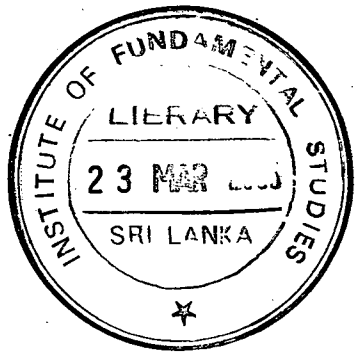
2004



Institute of Fundamental Studies
Hantana Road
Kandy

INSTITUTE OF FUNDAMENTAL STUDIES

ANNUAL RESEARCH REPORT 2004



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PUBLICATIONS IN REFEREED JOURNALS 2004

A. Publications by Resident Scientists:

1. Athauda S.B.P., Matsumoto K., Rajapakshe S., Kuribayashi M., Kojima M., Kubomura–Yoshida N., Iwamatsu A., Shibata C., Inoue H., and Takahashi K. Enzymic and structural characterization of nepenthesin, a unique member of a novel subfamily of aspartic proteinases. ***Biochemical Journal,* 381:** 295 (2004).[1,2]

2. **Bandara J.** and Weerasinghe H. Solid-state dye-sensitized solar cell with p-type NiO as a hole collector. ***Solar Energy Materials and Solar Cells,*** (in press). [1,2]

3. ***Bandara J.**, Divarathne C.M., and Nanayakkara S.D. Fabrication of n-p junction electrodes made of n-type SnO_2 and p-type NiO for control of charge recombination in Dye Sensitized Solar Cells. ***Solar Energy Materials and Solar Cells*, 81(4):** 429 (2004).[1,2]

4. ***Bandara J.**, Hadapangoda C., and **Jayasekera W.G.** TiO_2/MgO composite photocatlyst: The role of MgO in photoinduced charge carrier separation. ***Applied Catalysis B: Environmental,* 50:** 83 (2004). [1,2]

5. **Bandara J.**, Pradeep U.W., and Bandara R.G.S.J. The role of n–p junction electrodes in minimizing the charge recombination and enhancement of photocurrent and photovoltage in dye sensitized solar cells. ***Journal of Photochemistry and Photobiology A: Chemistry,*** (in press). [1,2]

6. **Bandara J.** and Weerasinghe H. Enhancement of Photovoltage of Dye Sensitized Solid-state Solar cells by introducing high-band gap oxide layers. ***Solar Energy Materials and Solar Cells,*** (in press).[1,2]

7. **Bandara J.** and Weerasinghe H. Employing NiO as a hole collector in Solid-state dye-sensitized solar cell. ***Institute of Physics Sri Lanka,*** (in press).

8. **Bandara J.** and Weerasinghe H. Efficient Solid-state dye sensitized solar cells fabricated on a compact TiO_2 barrier layer preventing short-circuit current. ***Institute of Physics Sri Lanka,*** (in press).

9. **Bandaranayake K.M.P., Seneviratne M.K.I.**, Weligamuwa P.M.G.M., and **Tennakone K.** Dye-sensitized solar cells made from nanocrystalline TiO_2 films coated with outer layers of different oxide materials. ***Coordination Chemistry Reviews*, 248**: 1277 (2004). [1,2]

10. Dallavalle S., **Jayasinghe L.**, Kumarihamy B.M.M., Merlini L., MussO L., and Scaglioni L. New 3,4-*seco*-lupane derivative from *Lasianthus gardneri*. ***Journal of Natural Products*, 67**: 911 (2004). [1,2]

11. **Dharmaratne H.R.W.**, Tennakoon S.B., and **Piyasena K.G.N.P.** A Geranylated biphenyl derivative from Garcinia mangostana. ***Natural Product Research,*** (in press).[2]

12. Fukuri N., Saito Y., Kubo W., **Senadeera R.**, Kitamura T., Wada Y., and Yanagida S. Improvement of the Performance of Solid-State Dye-Sensitized Solar Cells Fabricated Using Poly(3,4-ethylenedioxythiophene) and an Amphiphilic Sensitizing Dye. ***Journal of The Electrochemical Society,*** **151(10):** A1745 (2004).[1,2]

13. Hideki W., **Kehelpannala K.V.W.**, and Satish-Kumar M. Isotopic zonations in graphite and calcite and their implications for crustal evolution of Gondwana continents. ***Gondwana Research,*** **7:** 1397 (2004).[2]

14. Hoch M. and **Weerasooriya R.** Modeling interactions of kaolinite-tributyl tin interface. ***Chemosphere,*** (in press).[1,2]

15. Hoch M. and **Weerasooriya R.** New model calculations of pH depending tributyltin (TBT) adsorption onto monmorillonite and monmorillonite -rich sediment. ***Environmental Science and Technology,*** (in press).[1,2]

16. ***Iqbal M.C.M.**, **Jayasinghe U.L.B.**, Herath H.M.T.B., **Wijeysekara K.B.**, and Fujimoto Y. A fungistatic chromene from *Ageratum conyzoides Ageratum.* ***Phytoparasitica,*** **32(2):** 119 (2004).[1,2]

17. **Jayasinghe L.**, Balasooriya B.A.I.S., Padmini W.C., and Fujimoto Y. Geranyl chalcone derivatives with antifungal and radical scavenging properties from the leaves of *Artocarpus nobilis.* ***Phytochemistry,*** **65:** 1287 (2004).[1,2]

18. ***Jayasinghe U.L.B.**, Balasooriya B.A.I.S., Bandara A.G.D., and Fujimoto Y. Glycosides from *Grewia damine* and *Filicium decipiens.* ***Natural Product Research,*** **18(6):** 499 (2004).[2]

19. **Jayasinghe U.L.B.,** Balasooriya B.A.I.S., Hara N., and Fujimoto Y. Steroidal and triterpenoidal saponins from the fruits of *Diploclisia glaucescens.* ***Natural Product Research,*** (in press).[2]

20. ***Jayasinghe U.L.B.**, Puvanendran S., Hara N., and Fujimoto Y. Stilbene derivatives with antifungal and radical scavenging properties from the stem bark of *Artocarpus nobilis.* ***Natural Product Research,*** **18(6):** 571 (2004).[2]

21. **Jayasinghearachchi H.S.** and **Seneviratne G.** A bradyrhizobial-*Penicillium* spp. biofilm with nitrogenase activity improves N_2 fixing symbiosis of soybean. ***Biology and Fertility of Soils,*** **40:** 432 (2004).[1,2]

22. **Jayasinghearachchi H.S.** and **Seneviratne G.** Can mushrooms fix atmospheric nitrogen? ***Journal of Biosciences,*** **29:** 293 (2004).[1,2]

23. **Jayaweera P.V.V.**, **Perere A.G.U.**, **Seneviratne M.K.I.**, **Pitigala P.K.D.D.P.**, and **Tennakone K.** Dye-sensitized near-infrared room temperature photovoltaic photon detectors. ***Applied Physics Letters,*** (in press).[1,2]

24. **Kehelpannala K.V.W.** Arc accretion around Sri Lanka during the assembly of Gondwana. ***Gondwana Research,*** **7:** 1323 (2004).[2]

25. ***Kehelpannala K.V.W.** Structural Evolution of the middle to lower crust in Sri Lanka. ***Journal of the Geological Society of Sri Lanka,*** **11:** 45 (2004).

26. *Kumara G.R.R.A., Okuya M., Murakami K., Kaneko S., **Jayaweera P.V.V.**, and **Tennakone K.** Dye-sensitized solid-state solar cells made from magnesium ozide-coated nanocrystalline titanium dioxide. ***Journal of Photochemistry and Photobiology : A Chemistry,*** **164:** 183 (2004).[1,2]

27. Li I., **Bandara J.**, and Shultz M.J. Time Evolution Studies of the H2O/Quartz Interface Using Sum Frequency Generation, Atomic Force Microscopy and Molecular Dynamics. ***Langmuir,*** **20:** 10474 (2004).[1,2]

28. **Nanayakkara A.** and **Wickramarachchi P.** Level spacing distributions and quantum chaos in Hermitian and non Hermitian systems. ***Communications in Theoretical Physics,*** (in press).[1,2]

29. **Nanayakkara A.** A new way of finding locations of zeros of wave functions ***Canadian Journal of Physics,*** **82:** 549 (2004).[1,2]

30. **Nanayakkara A.** Classical trajectories of 1-D complex non-Hermitian Hamiltonian systems. ***Journal of Physics A: Mathematics and General,*** **37:** 4321 (2004).[1,2]

31. **Nanayakkara A.** Comparison of quantal and classical behavior of *PT*-symmetric systems at avoided crossings. ***Physics Letters A,*** (in press).[1,2]

32. **Nanayakkara A.** New Semiclassical and Numerical approaches to locate zeros of wave functions. ***Communications in Theoretical Physics,*** (in press).[1,2]

33. **Nanayakkara A.** Reality of energy spectra in multi dimensional Hamiltonians having pseudo Hermiticity with respect to the exchange operator. ***Communications in Theoretical Physics,*** **42:** 693 (2004).[1,2]

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35. ***Nanayakkara A.** Semi-classical Studies of Complex Non-Hermitian Hamiltonian Systems. ***Czechoslovak Journal of Physics,*** **54:** 101 (2004).[1,2]

36. **Nanayakkara A.** Zeros of the wave functions of general polynomial potentials. ***Canadian Journal of Physics,*** **82:** 1067 (2004).[1,2]

37. Osanai Y., Sajeev K., Owada M., **Kehelpannala K.V.W.**, Prame W.K.B.N., and Nakano N. Metamorphic evolution of high pressure and ultrahigh-temperature granulites from the Highland Complex, Sri Lanka. ***Journal of Asian Earth Sciences,*** *Special Issue,*(in press).[2]

38. *Perera V.P.S., **Jayaweera P.V.V.**, **Pitigala P.K.D.D.P.**, **Bandaranayake P.K.M.**, Hastings G., **Perera A.G.U.**, and **Tennakone K.** Construction of a photovoltaic device by deposition of thin films of the conducting polymer polythiocyanogen. ***Synthetic Metals,*** **143:** 283 (2004).[1,2]

39. **Perera V.P.S.**, **Pitigala P.K.D.D.P.**, **Seneviratne M.K.I.**, and **Tennakone K.** A solar cell sensitized with three different dyes. ***Solar Energy Material and Solar Cells,*** **85:** 91 (2004).[1,2]

40. **Perera V.P.S.**, **Seneviratne M.K.I.**, **Pitigala P.K.D.D.P.**, and **Tennakone K.** Doping CuSCN Films for Enhancement of conductivity: Application in Dye-sensitized Solid-state solar cells. ***Solar Energy Materials and Solar Cells,*** (in press).[1,2]

41. ***Perera V.P.S.**, **Pitigala P.K.D.D.P.**, **Jayaweera P.V.V.**, **Bandaranayake K.M.P.**, and **Tennakone K.** Dye-sensitized Solid-state Photovoltaic Cells Based on Dye-multilayer Semiconductor Nanostructures. ***Journal of Physical Chemistry*** **B, 107**: 13758 (2004).[1,2]

42. **Pitigala P.K.D.D.P.**, **Seneviratne M.K.I.**, **Perera V.P.S.**, and **Tennakone K.** Dye-Multilayer semiconductor Nanostructures. ***Comptes Rendus Chemie,*** (in press).[1,2]

43. **Pitigala P.K.D.D.P.**, **Seneviratne M.K.I.**, **Perera V.P.S.**, and **Tennakone K.** Sensitization of Nanostructured TiO_2 by Electostatic Coupling of Ionic Dyes to Ionic Absorbates. ***Langmuir,*** **20**: 5100 (2004).[1,2]

44. *Rott E., **Silva E.I.L.**, Enriquez E., and Igthamjitr S. Phytoplankton community structure (species composition, diversity, chlorophyll, seasonal variations and key stone variables) in four reservoirs and a volcanic lake in Monsoon Asia. ***Hydrobiologia,*** (in press).[1,2]

45. *Sakagami Y., Iinuma M., Piyasena K.G.N.P., and **Dharmaratne H.R.W.** Antibacterial activity of α-Mangostin against Vancomycin Resistant *Enterococci* (VRE) and Synergism with Antibiotics. ***Phytomedicine,*** (in press).[2]

46. *Saito Y., Fukuri N., **Senadeera R.**, Kitamura T., Wada Y., and Yanagida S. Solid State dye sensitized solar cells using in situ polymerized PEDOTs as hole conductor. ***Electrochemistry Communications,*** **6:** 71 (2004).[1,2]

47. **Senadeera G.K.R.** and **Pathirathne W.M.T.C.** Utilization of conducting polymer as a sensitizer in solid-state photocells. ***Current Science,*** **87(3):** 339 (2004).[1,2]

48. **Senadeera G.K.R.** and **Perera V.P.S.** Photoresponses of electrodes prepared by CuSCN with electrodeposited C_{60} on mesoporous TiO_2. ***Chinese Journal of Physics,*** (in press). [1,2]

49. **Senadeera G.K.R.** Microwave assisted steps in the synthesis of poly(3-thiophenyl) acetic acid. ***Current Science,*** (in press). [1,2]

50. **Senadeera G.K.R.** Spray–painted nanostructured TiO_2 electrodes for solid-state dye sensitized photocells. ***Sri Lanka Journal of Physics,*** (in press).

51. **Senadeera G.K.R.** and Mori T. A new crystal structure for (BEDT-TTF)2SbF6 and some of its physical properties. ***Bulletin of Materials Science,*** (in press).[2]

52. **Senadeera G.K.R.**, Kitamura T., Wada Y., and Yanagida S. Deposition of polyaniline via molecular self-assembly on TiO_2 and its uses as a sensitiser in solid-state solar cells. ***Journal of Photochemistry and Photobiology A: Chemistry,*** **164:** 61 (2004). [1,2]

53. ***Seneviratne G.** and **Nanayakkara A.** Isotope/element fractionation during surface adsorption. ***American Journal of Physics,*** **72:** 73 (2004). [1,2]

54. **Seneviratne M.K.I.**, **Pitigala P.K.D.D.P.**, and **Tennakone K.** Water photoreduction with Cu_2O Quantum Dots on TiO_2 Nano-Particles. ***Journal of Photochemistry and Photobiology: A Chemistry,*** (in press). [1,2]

55. Seneviratne S.N. de S. and **Jeyanandarajah P.** Rice diseases – Problems and progress. ***Tropical Agricultural Research and Extension,*** (in press).

56. ***Silva E.I.L.**, Ekanayake M., and **Karunathilake K.M.B.C.** Seasonal abundance of two species of rotifers (*Brachionus calyciflorus* and *Keratella tropica*) in a tropical urban water body, Kandy Lake in Sri Lanka. ***Sri Lanka Journal of Aquatic Sciences,*** **8:** 51 (2003).

57. **Silva E.I.L.** and Shimizu A. Concentration of Trace metals in the flesh of nine species of fish found in hydropower reservoirs in Sri Lanka. ***Asian Fisheries Science,*** **17(3-4):** 256 (2004).

58. **Silva E.I.L.** and Manuweera L. Surface and Rainwater Chemistry in Sri Lanka – a risk of acidification. ***Asian Journal of Water, Environment and Pollution,*** **1:** 79 (2004).

59. **Silva E.I.L.** and Samaradiwakara S.R.M.S. Limnology of Kandy Lake Before the Outbreak of Cyanaobacteria Bloom 1. Physicochemical limnology. ***Sri Lanka Journal Aquatic Science,*** **9:** 69 (2004).

60. **Silva E.I.L.** and Samaradiwakara S.R.M.S. Limnology of Kandy Lake Before the Outbreak of Cyanaobacteria Bloom II. Photosynthetic characteristics and primary production. ***Sri Lanka Journal Aquatic Science,*** **9:** 91 (2004).

61. **Silva E.I.L.** Quality of irrigation water in Sri Lanka- status and trends. ***Asian Journal of Water, Environment and Pollution,*** **1:** 5 (2004).

62. **Silva E.I.L.** Ecology of Phytoplankton in Tropical waters: Introduction to the topic and ecosystem changes from Sri Lanka. ***Asian Journal of Water, Environment and Pollution,*** (in press).

63. Sun Y.P., Atorngitjawat P., Lin Y., Liu P., Pathak P., **Bandara J.**, Elgin D., and Zhang M.Z. Nanoscale cavities in ionomer membrane for the formation of nanoparticles. ***Journal of Membrane Science,*** **245 (1):** 211 (2004). [1,2]

64. **Tennakone K.** and **Wijayantha K.G.U.** Photocatalysis of CFC degradation by titanium dioxide. ***Applied Catalysis B: Environmental,*** (in press). [1,2]

65. *Vijverberg J., Amarasinghe P.B., Chittapalapong T., Pagulayan R.C., Ariyaratne M.G., Pamanian E.R., **Silva E.I.L.**, and Nagelkerke L.A.J. Structure of micro-crustacean zooplankton communities in five south-east Asian water bodies. ***Hydrobiologia,*** (in press). [1,2]

66. ***Weerasooriya R.**, Tobshcall H.J., Wijesekara D., and Bandara A. Macroscopic and Vibration Spectroscopic Evidence for Specific Bonding of Arsenate on Gibbsite. ***Chemosphere,*** **55:** 1259 (2004). [1,2]

67. *Willbold M., Hegner E., **Kleinschrodt R.**, Stosch H.G., **Kehelpannala K.V.W.**, and Dulski P. Geochemical evidence for a Neoproterozoic magmatic continental margin in Sri Lanka - Relevance for the Rodinia-Gondwana supercontinent cycle. ***Precambrian Research,*** **130:** 185 (2004). [1,2]

68. Yanagida S., **Senadeera G.K.R.**, Nakamura K., Kitamura T., and Wada Y. Polythiophene Sensitized TiO_2 Solar Cells. ***Journal of Photochemistry and Photobiology A: Chemistry,*** **166**: 75 (2004). [1,2]

69. Zarnowski R.A., Jaromin M., Certik T., Czabany J., Fontaine T., Jakubik, **Iqbal M.C.M.**, Grandmougin-Ferjani A., Kozubek A. and Pietr S.J. The oil of *Adenanthera pavonina* L. seeds and its emulsions. ***Zeitschrift für Naturforschung,*** **59c:** 321 (2004). [1,2]

B. Publications by Visiting Scientists:

70. Abbot C., **Fernando G.W.**, and Rasamny M. Reduction of the three dimensional Schrodinger equation for multilayered films. ***Physics Review B,*** **69:** 205412 (2004). [1,2]

71. ***Dias H.V.R.** and Goh T.K.H.H. Fluorinated Tris(pyrazolyl)borates. Syntheses and Characterization of Sodium and Copper Complexes of [HB(3-(CF_3),5-(Ph)Pz)$_3$]. ***Polyhedron*** *(Invited Paper for Special Issue on Scorpionates),* **23:** 273 (2004). [1,2]

72. **Dias H.V.R.** and Singh S. Copper(I) Complexes of Fluorinated Triazapentadienyl Ligands: Synthesis and Characterization of $[N\{(C_3F_7)C(Dipp)N\}_2]CuL$ (where L = $NCCH_3$, $CNBu^t$, CO; Dipp = 2,6-diisopropylphenyl). ***Inorganic Chemistry,*** **43:** 5786 (2004). [1,2]

73. **Dias H.V.R.** and Wang X. Sterically Demanding Methyl Tris(pyrazolyl)borate Ligands: Synthesis and Characterization of Thallium(I) Complexes Supported by [MeB(3-(*t*-Bu)Pz)$_3$] and [MeB(3-(Mes)Pz)$_3$]. ***Polyhedron,*** **23:** 2533 (2004).[1,2]

74. **Dias H.V.R.**, Richey S.A., Diyabalanage H.V.K., and Thankamani J. Copper(I) Complexes Supported by a Heavily Fluorinated Bis(pyrazolyl)borate: Syntheses and Characterization of [H_2B(3,5-$(CF_3)_2Pz)_2$]CuL (Where L = PPh_3, $N{\equiv}CCH_3$, $HC{\equiv}CPh$, $H_2C{=}CHPh$) and {[H_2B(3,5-$(CF_3)_2Pz)_2$]Cu}$_2$(1,5-COD). ***Journal of Organometallic Chemistry,*** (in press).[1,2]

75. Ekanayake D.K., Rajapakse R.P.V.J., Dubey J.P., and **Dittus W.P.J.** Seroprevalence of *Toxoplasma gondii* in Wild Toque Macaques (*Macaca sinica*) at Polonnaruwa, Sri Lanka. ***Journal of Parasitology,*** **90(4):** 870 (2004).[1,2]

76. Hu S., Goldman D.I., Kouri D.J., Hoffman D.K., Swinney H.L., and **Gunaratne G.H.** Stages of Relaxation of Patterns and the Role of Stochasticity on the Final Stage. ***Nonlineartiy,*** **17(4):** 1535 (2004).[1,2]

77. †**Kleinschrodt R.** Metasomatic calcsilicate rocks: an example of infiltration metasomatism from the highland complex of Sri Lanka. ***Journal of the Geological Society of Sri Lanka,*** **11:** 21 (2003).

78. *Rajapaksa C.S., Thomsen J.S., Espinoza-Ortiz J.S., Wimalawansa S.J., Ebbesen E.N., Mosekilde L., and **Gunaratne G.H.** An Expression Relating Breaking Stress and Density of Trabecular Bone. ***Journal of Biomechanics,*** **37:** 1241 (2004).[1,2]

79. ***Yoshida M.**, Tani Y., Rajesh H.M., and Santosh M. Diversity in the position of Sri Lanka within the Gondwanaland ensemble. ***Journal of the Geological Society of Sri Lanka,*** **11:** 5 (2003).

Total number of publications for year 2004 -57
Twenty two articles appeared as "in press" in the Annual Research Report 2003

Names of the IFS staff members are in bold letters
† *This article did not appear in Annual Research Report 2003*
* *Reported as "in press" in the Annual Research Report 2003*
1 *Listed in the Science Citation Index in 2004*
2 *Listed in the Science Citation Index expanded in 2004*

IMPACT FACTORS OF JOURNALS IN WHICH, THE ARTICLES ARE PUBLISHED

(Impact factors are computed to an accuracy of three decimal places, X: Impact Factor not computed for the year 2003)

JOURNAL	IMPACT FACTOR
American Journal of Physics	*0.792*
Applied Catalysis B: Environmental	*3.476*
Applied Physics Letters	*4.049*
Asian Fisheries Science	*X*
Asian Journal of Water, Environment and Pollution	*X*
Biochemical Journal	*4.101*
Biology and Fertility of Soils	*1.152*
Bulletin of Materials Science	*0.529*
Canadian Journal of Physics	*0.777*
Chemosphere	*1.904*
Chinese Journal of Physics	*0.372*
Communications in Theoritical Physics	*0.666*
Comptes Rendus Chemie	*0.518*
Coordination Chemistry Reviews	*5.951*
Current Science	*0.694*
Czechoslovak Journal of Physics	*0.263*
Electrochemistry Communications	*2.300*
Environmental Science and Technology	*3.592*
Gondwana Research	*1.208*
Hydrobiologia	*0.720*
Inorganic Chemistry	*3.389*
Institute of Physics Sri Lanka	*X*
Journal of Asian Earth Sciences	*0.853*
Journal of Physics A: Mathematics and General	*1.357*
Journal of Biomechanics	*2.005*
Journal of Biosciences	*0.720*
Journal of Membrane Science	*2.081*
Journal of Natural Products	*1.849*
Journal of Organometallic Chemistry	*2.042*
Journal of Parasitology	*1.137*
Journal of Photochemistry and Photobiology A: Chemistry	*1.693*
Journal of Physical Chemistry B	*3.679*
Journal of The Electrochemical Society	*2.361*
Journal of The Geological Society of Sri Lanka	*X*
Langmuir	*3.098*
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Phytochemistry	*1.889*
Phytomedicine	*1.138*

JOURNAL	IMPACT FACTOR
Phytoparasitica	*0.653*
Polyhedron	*1.584*
Precambrian Research	*2.947*
Solar Energy Materials and Solar Cells	*1.188*
Sri Lanka Journal of Aquatic Sciences	*X*
Sri Lanka Journal of Physics	*X*
Synthetic Metals	*1.303*
Tropical Agricultural Research and Extension	*X*
Zeitschrift für Naturforsch C	*0.642*

PROJECT: **APPLIED MATHEMATICS**
DEVELOPMENT OF DIAGNOSTICS FOR OSTEOPOROSIS

COMMENCEMENT: 1999

INVESTIGATORS (2004):

Gunaratne G.H., *Visiting Research Professor* **(Project Leader)**

PROGRESS ACHIEVED *(Since inception):*

Osteoporosis is a systemic skeletal disease, which increases the fragility of bone and its susceptibility to fracture. Osteoporosis related fractures in the US are estimated to number several million and cost tens of billions of dollars annually in therapy and rehabilitation. More seriously, the lack of mobility during recovery period can initiate secondary ailments such as pneumonia, causing a 20-25% mortality rate within a year following a fracture. Unfortunately, most therapeutic agents available to reduce bone loss have adverse side effects. Hence, reliable diagnostic tools to determine the need and optimal time for therapeutic intervention are critical for management of the disease.

Bone density, which is currently the principal clinical means for detecting osteoporosis, is known to only partially account for strength. The stress carrying capabilities of bone depend on additional factors such as the fragility of the material forming the outer solid shaft of a bone and levels of connectivity and anisotropy of the inner porous bone; the last two factors are particularly important because porous bone is the principle load carrier in bones of older subjects. Reliability of diagnostic tools can only be enhanced by properly accounting for consequences of these multiple facets. This task is impossible to achieve using bone samples, since there is no way to implement controlled changes in animal or human bones.

I have introduced an approach that begins with an analysis of model systems to identify factors that cause most severe degradation of bone. Once the physical mechanisms are known, methods from fracture mechanics and statistical physics are used to search for surrogates for fracture load. The conclusions are then tested using digitized images of bone obtained from micro-computed tomography as well as in experiments on cadaver and animal bone samples. These experimental studies are conducted in collaboration with Professor Michael Liebschner (Department of Bioengineering, Rice University) and Professor Sunil Wimalawansa (Chief, Division of Endocrinology, Metabolism and Nutrition, Robert Wood Johnson Medical School). Finally, diagnostic tests based on these surrogates will be developed and tested.

Our model of porous bone consists of a disordered cubic network of struts and nodes. We have shown that, among known age-related changes, removal of struts causes most damage to bone. Occasional long fractures formed during strut removal drastically reduces the number of pathways along which stress can be propagated, thus making the remaining bone highly inefficient at load transmission. Calculations

based on this observation were used to derive a new expression for bone strength. Data from a large Danish study on cadaver bone samples was shown to be very well represented by this expression. Furthermore, we showed that the ratio Γ of the elastic modulus of a network and its linear response to high frequency driving can be used to estimate the level of efficiency in stress transmission, and hence is a reliable surrogate for fracture load. We have proposed animal studies (to be conducted in the laboratory of Prof. Wimalawansa) to test this assertion.

We are currently conducting numerical and experimental studies on cadaver bone samples from several anatomical locations to test model-based conclusions. Numerical methods use, computer models of bone samples constructed from digitized images (obtained in laboratory of Prof. Liebschner). Analyses of these models have confirmed that, as in the struts- and-nodes system, reduction in the number of stress pathways is the principal reason for loss of strength. The predicted expression for bone strength and the reliability of Γ as a diagnostic for strength were also confirmed in these studies. Experimental studies on cadaver bone samples, initiated in the laboratory of Prof. Liebschner, involve the application of vibrational and ultrasonic techniques. We have begun experiments using a computer-controlled vibrator, which measures the response using a piezoelectric transducer. In addition, digitized images will be used to construct synthetic prototypes with uniform material properties. Experiments on bone samples and these prototypes will be used to compare the relative importance of changes in architecture and in material properties (levels of mineralization and micro-damage). Further, since predetermined structural changes can be made on prototypes, we can use experiments to validate theoretical and model-based conclusions on effects of variations relevant for bone strength. Finally, animal studies are planned in the laboratory of Prof. Wimalawansa to test whether our predictions capture therapeutically induced loss of strength in rat bones.

Analyses of struts-and-nodes models and those constructed from digitized images of bone samples point to a pair of important new observations, namely (1) most serious damage of bone is caused by larger fractures, and (2) vibrational analysis, in particular linear response functions, can be used to predict the level of decay. They motivate the search for additional surrogates of bone strength based on results from statistical physics such as the fluctuation-dissipation theorem and Kubo formulae. Dr. Yan Song, a post-doc who will join my group, will conduct the studies. Further, these observations point out to a need for a comprehensive vibrational analysis of bone. Such a study combining computations on model systems and digitized images as well as experiments on bone samples and prototypes has been undertaken.

Our studies have also provided new results on the strength of percolation networks. We have developed new computational techniques to calculate critical indices that quantify how peak currents in fused electrical networks vanish. Rather surprisingly, it was found that these critical indices are not universal. A recent post-doc in my group, Dr. J. Espinoza-Ortiz, is completing an analysis of the relevant perturbations of the fixed point and the flow in its neighborhood, with the aim of determining the origin of non-universality.

Analysis and Characterization of Natural Patterns

From electrical currents in heart muscles to geological formations, nature abounds with spatiotemporal patterns. On occasion, it is important to know if any useful information can be extracted from these patterns. For example, can a pattern of cell growth be used to detect an abnormality? Can such descriptions be quantified? Details of these complex structures typically depend not only on the underlying physical system, but also on (uncontrollable) initial conditions. Hence, prior to addressing the issue of the content in a pattern, it is important to identify suitable statistical variables that can provide characterizations that are independent of the initial state. Most concepts from statistical mechanics do not carry over because the patterns are non-equilibrium states and the underlying physical systems are -typically -irreversible.

Over the last several years, my research group has developed a scheme to deduce classes of measures that can be used to characterize complex patterns. The analysis begins by quantifying the local "amount of disorder"; possible forms are restricted by the requirement that measures remain unchanged when the entire pattern is translated, rotated or reflected; i.e., they need to be invariant under Euclidean motions. This condition imposes severe limitations on possible functionals that can be used for a statistical analysis. One such disorder field can be formed using the local curvature of contour lines. After the "disorder" field is constructed, an analog of the "Thermodynamic Formalism" (of D. Ruelle et.al.) can be used to form a family of functionals to be used in quantifying spatial and spatio-temporal characteristics.

The first application of the methodology was in "textured" patterns; i.e., complex patterns that consist of patches of a simple structure such as stripes or hexagons. The local disorder is obtained from the Helmholtz operator, and the family of measures is referred to as the "disorder function" $\delta(\beta)$. Distinct values of β emphasize multiple aspects of a pattern; e.g., the mean curvature, domain size, defect density. Disorder function analysis was used to show that pattern relaxation in model systems occurs in three distinct stages, and that the stages II and III only differ in systems with stochasticity. These conclusions were validated in experiments (done in the laboratory of Professor Harry Swinney at the University of Texas, Austin) on a pattern forming chemical system and on a vibrated layer of granular material.

New image processing techniques, based on a Hermite polynomial basis, had to be developed to conduct the analysis of (noisy) experimental patterns. Some of these filtering techniques were shown to have a broad range of applicability and were subsequently patented.

The second application, which is being implemented by a graduate student in my group, is an analysis of domain growth in processes like spinodal decomposition and epitaxial growth. Unlike textured patterns, these do not have a well-defined local structure. For this case, the local disorder is estimated using the determinant of the Hessian matrix of the field representing the pattern. Preliminary studies have shown that patterns generated by the Cahn-Hilliard system follow four distinct stages of relaxation. We have also used these measures to identify non-universal statistical properties of spatio-temporal dynamics in the Kardar-Parisi-Zhang class of models.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1.* *Title:* An Expression Relating Breaking Stress and Density of Trabecular Bone

Authors: Rajapaksa C.S., Thomsen J.S., Espinoza-Ortiz J.S., Wimalawansa S.J., Ebbesen E.N., Mosekilde L., and **Gunaratne G.H.**

Journal: ***Journal of Biomechanics***, **37**: 1241 (2004) [1,2]

2. *Titile:* Stages of Relaxation of Patterns and the Role of Stochasticity on the Final Stage

Authors: Hu S., Goldman D.I., Kouri D.J., Hoffman D.K., Swinney H.L., and **Gunaratne G.H.**

Journal: ***Nonlineartiy,*** **17(4):** 1535 (2004) [1,2]

* ***Reported as 'in press' in Annual Report 2003***

[1] ***Listed in the Science Citation Index in 2004***

[2] ***Listed in the Science Citation Index-expanded in 2004***

PROJECT: **COMPUTATIONAL MATHEMATICS AND PHYSICS**
(I) QUANTUM CHAOS

COMMENCEMENT: 2000

INVESTIGATORS (2004):

Nanayakkara A., *Associate Research Professor* **(Project Leader)**
Wickramararchchi P., *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

In recent years, the manifestation of chaos in quantum mechanics have been of great interest. In particular, quantum systems which are classically chaotic have been investigated intensively. In order to study signature of chaos in quantum mechanics, we have been developing various theoretical and computational methods for multidimensional systems which bridge classical mechanics with quantum mechanics in a transparent manner. Also we have been investigating quantum mechanical quantities which contain information on chaos in the corresponding classical system. Major achievements of this project since its inception (till end of the year 2003) can be summarized as follows:

(1) A new powerful asymptotic energy expansion method was developed for 1-D systems. This method is based on power series expansion of the quantum action variable J in energy and can be applied to a wide range of potentials. Contour integrals involved in the method are much simpler than that in WKB methods.

(2) A new quantization condition was developed for 1-D systems. This new method is a computational method which can be applied to large number of 1-D systems.

(3) The semi-classical concepts and methods which are normally used for studying semi-classical chaos in real phase-space were extended to complex phase-space for studying both PT-symmetric and pseudo Hermitian systems. It is found that most of the semi-classical methods which have been developed for quantizing multi-dimensional real Hermitian Hamiltonian systems can be successfully employed for complex non-Hermitian PT-symmetric systems with suitable extensions

(4) Several 1-D and 2-D pseudo Hermitian Hamiltonian systems have been studied. The Lyapunov exponents and classical phase space trajectories were used to distinguish regular motion from chaotic ones. The quantum energy level statistics were used to identify quantum signatures of classically chaotic motion.

(5) A new analytical method was developed for locating zeros of wave functions. In this method locating zeros of the wave function is converted to finding roots of a polynomial whose coefficients are obtained as analytical expressions.

PROJECT OUTPUT 2004:

In 2004, we investigated distribution of zeros of quantum wave functions and second differences of energy at avoided crossings. We developed new approximation and numerical methods for locating zeros of wave functions. The distribution of zeros of wave functions in multidimensions are believed to contain signature of chaos in the corresponding classical system. Second differences of energy levels at avoided crossings of multidimensional pseudo Hermitian systems were studied to establish a connection between classical chaos and behavior of quantum eigen states at avoided crossings. Applicability of very high order non-degenerate perturbation theory for studying energy levels of multidimensional systems near avoided crossings were also investigated.

This project has produced 20 research papers and 3 research communications during last four years.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Level spacing distributions and quantum chaos in Hermitian and non Hermitian systems
   Authors: **Nanayakkara A.** and **Wickramarachchi P.**
   Journal: ***Communications in Theoritical Physics,*** 2004 *(in press)*[1,2]

2. *Title:* Zeros of the wave functions of general polynomial potentials
   Author: **Nanayakkara A.**
   Journal: ***Canadian Journal of Physics,*** **82:** 1067 (2004)[1,2]

3. *Title:* Comparison of quantal and classical behavior of *PT*-symmetric systems at avoided crossings
   Author: **Nanayakkara A.**
   Journal: ***Physics Letters A,*** 2004 *(in press)*[1,2]

4. *Title:* New Semiclassical and Numerical approaches to locate zeros of wave functions
   Author: **Nanayakkara A.**
   Journal: ***Communications in Theoritical Physics,*** 2004 *(in press)*[1,2]

5. *Title:* Semiclassical Chaos in a 2-D Exactly Solvable system
   Author: **Nanayakkara A.**
   Journal: ***Sri Lanka Journal of Physics,*** 2004 *(in press)*

6. *Title:* Reality of energy spectra in multi dimensional Hamiltonians having pseudo Hermiticity with respect to the exchange operator
Author: **Nanayakkara A.**
Journal: ***Communications in Theoritical Physics,* 42:** 693 (2004)[1,2]

7. *Title:* Classical trajectories of 1-D complex non-Hermitian Hamiltonian systems
Author: **Nanayakkara A.**
Journal: ***Journal of Physics A: Mathematics and General,* 37:** 4321 (2004)[1,2]

8. *Title:* A new way of finding locations of zeros of wave functions
Author: **Nanayakkara A.**
Journal: ***Canadian Journal of Physics,* 82:** 549 (2004)[1,2]

9. * *Title:* Semi-classical Studies of Complex Non-Hermitian Hamiltonian Systems
Author: **Nanayakkara A.**
Journal: ***Czechoslovak Journal of Physics,* 54:** 101 (2004)[1,2]

10.* *Title:* Isotope/element fractionation during surface adsorption
Authors: **Seneviratne G.** and **Nanayakkara A.**
Journal: ***American Journal of Physics,* 72:** (2004) [1,2]

* ***Reported as 'in press' in Annual Report 2003***
[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. **Nanayakkara A.** and **Wickramarachchi P.**
Level spacing distributions of 1-D potentials with non integer powers
20th Technical Session, Institute of Physics Sri Lanka 2004

INVITED LECTURES/CONFERENCES ATTENDED IN 2004:

1. **Nanayakkara A.**
Analytic Asymptotic Expansions of Energies and Level Spacing Distributions
Ruhuna International School on Computational and Mathematical Physics (RISCMAP) 2004

2. **Nanayakkara A.**

Application of high order non-degenerate perturbation theory near avoided crossings of irregular quantum states.

Ruhuna International School on Computational and Mathematical Physics (RISCMAP) 2004

OTHER CONTRIBUTIONS:

Science and Technology Promotion

English-Sinhala Science glossary (electronic) with an intelligent search engine was published in compact disc form jointly with Science Dissemination Unit. This contains about 41,800 words in the field of Biology, Chemistry, Physics and Mathematics.

Development of English-Tamil glossary is in progress. Data files for Biology and Mathematics were completed and remaining data files are in preparation.

PROJECT: **COMPUTATIONAL MATHEMATICS AND PHYSICS**

(II) COMPUTER SIMULATION OF ELECTROPHYSIOLOGICAL ACTIVITIES IN HUMAN BRAIN

COMMENCEMENT: 2002 (August)

INVESTIGATORS (2004):

Nanayakkara A., *Associate Research Professor* **(Project Leader)**
Selvarajan S., *Lecturer, University of Jaffna*

PROGRESS ACHIEVED (*Since inception*):

As the first project in the area of computer simulation of electrophysiological activities in human brain, we investigated epilepsy. Epilepsy is a chronic medical condition produced by temporary changes in the electrical function of the brain, causing seizures which affect awareness, movement, or sensation. One of the signatures of the human epileptic brain during periods of time in between seizures is the presence of brief burst of focal neuronal activity known as interictal spikes. Often such spikes emanate from the same region of the brain from which the seizures are generated but the relationship between the spikes patterns and seizure onset remains unclear.

In this project we simulated some experiments using neural network models with chemical kindling and investigated how to control of the chaotic nature of the network. We developed and investigated several neural network models. We simulated both the normal and the epileptic brains with discrete and continues models. External stimuli to the neural work and the inclusion of additional Calcium and Potassium currents were studied in detail.

PROJECT OUTPUT 2004:

In 2004, Mr. Selvarajan completed and submitted his MPhil thesis. Manuscripts based on this research work are in preparation for submission to appropriate journals.

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. Selvarajan S., **Nanayakkara A.**, and Ranasinghe M.
   Effect of External Input Currents on Bursting in Neural Network Models
   20th Technical Session, Institute of Physics Sri Lanka

PROJECT: **COMPUTATIONAL MATHEMATICS AND PHYSICS**

(III) **COMPUTER AIDED DESIGNING OF NEW MATERIALS**

COMMENCEMENT: 2004

INVESTIGATORS (2004):

Nanayakkara A., *Associate Research Professor* **(Project Leader)**
Senadeera G.K.R., *Senior Research Fellow*
Senevirathe S.B.M.S., *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

Aim of this project is to design new materials with desirable electronic and physical properties using *ab initio* and semi-empirical computational methods. In this long term project, we are addressing the problem of calculating electronic structure properties of materials from three different fronts. They are

(1) Calculation of electronic structure properties using molecular based Density Functional Theory and other electronic structure methods.

(2) Calculation of electronic structure properties using Crystal molecular orbital based methods.

(3) Development of new theoretical methods to incorporate electronic exchange and correlation effects more accurately in Density Functional Theory.

PROJECT OUTPUT 2004:

Preliminary calculations based on Molecular Density Functional Theory were carried out for several conducting polymers and calculated both electronic band gaps and band positions of them. The calculated values are in fairly good agreement with the experimental values. We also predicted electronic band gaps and band positions of few new conducting polymers which have not yet been studied experimentally. The manuscripts based on these results are in preparation for submission to appropriate journals. Various types of conducting polymers are currently being investigated

In order to test our new theoretical methods, a software package based on Density Functional Theory (called **MOLDF**) are being developed. It will take about a year to complete this package.

GRANTS AND AWARDS:

Received a three year NSF grant to hire a research student to assist the development of Crystal Molecular Orbital based electronic structure code and to investigate materials which are having desired electronic band structures. This project will start from January 2005.

PROJECT: CONDENSED MATTER THEORY

COMMENCEMENT: 1999

INVESTIGATORS(2004):

Fernando G.W., *Visiting Research Professor* **(Project Leader)**

PROGRESS ACHIEVED (*Since inception*):

Over the past few years, we have been investigating fundamental aspects of first principles many body theory, including density functional theory. Some of this work was carried out with (former) students M. Rasamny and M. Valiev at the University of Connecticut and UC San Diego, respectively. During the summer 2000, we have had an undergraduate student from Cornell working on transport properties of magnetic heterojunctions. We have also been examining phase diagrams of various binary intermetallics from a theoretical point of view using first principles electronic structure theory with a former student of mine and colleagues at Brookhaven National Laboratory. Another one of our recent projects was related to developing systematic interatomic potentials and studying diffusion of actinides in metallic systems. This was in collaboration with Prof. B. R. Cooper at West Virginia University and Dr. Elena Sevilla at the University of Connecticut (UConn). During 2000-2002, we have had a collaboration on understanding catalytic systems with the IMS (Institute of Materials Science - UConn) and PCI (Precision Combustion Inc. in New Haven, CT). Recently, we have been trying to understand the electronic, magnetic and thermal properties of nanoclusters.

PROJECT OUTPUT 2004:

During the year 2004, I have been studying small Hubbard clusters with Dr. J.W. Davenport at Brookhaven National Lab and Dr. A.N. Kocharian at California State University. This has been done using, a) exact methods to evaluate the partition function and thermal averages of the two site, single orbital Hubbard model and, b) using the auxiliary field Quantum Monte Carlo (QMC) method. For the two-site model, we have obtained analytical results related to the effects of strong electron correlations on charge and spin gaps, magnetization and susceptibility. This system does not yield a net magnetization in the absence of an external magnetic field. For larger clusters such as a 14 site pyramid, we observe a strong tendency towards ferromagnetism with increasing electron-electron interaction strength from our QMC calculations. For a 14 site ring structure, there are indications of frustrated antiferromagnetic order.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Reduction of the three dimensional Schrodinger equation for multilayered films
   Authors: Abbot C., Rasamny M., and **Fernando G. W.**
   Journal: ***Physics Review B,* 69:** 205412 (2004)[1,2]

[1] ***Listed in the Science Citation Index in 2004***
[2] ***Lisied in the Science Citation Index-expanded in 2004***

PROJECT : CONDENSED MATTER PHYSICS

COMMENCEMENT : 1987

INVESTIGATORS (2004):

Tennakone, K., *Senior Research Professor* **(Project Leader)**
Queisser H.J., *Distinguished Visiting Research Professor*
Wijayantha K.G.U., *Visiting Senior Research Fellow*
Perera V.P.S., *Visiting Scientist*
Bandaranayake K.M.P., *Research Assistant*
Jayaweera P.V.V., *Research Assistant*
Pitigala P.K.D.D.P., *Research Assistant*
Seneviratne M.K.I., *Research Assistant*
Premalal E.V.A., *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

The aim of the project initiated around mid nineteen eighties was to conduct research in major areas of Condensed Matter Physics depending on the available facilities and personnel. In the first few years, a considerable effort was diverted to studies on high temperature superconductivity, which was then a fashionable theme of research. Subsequently project moved in the direction of semiconductor physics overlapping with the projects on photochemistry and solid-state chemistry. The project continues to conduct research on semiconductor thin films, nanostructures, low dimensional semiconductor and dye-sensitization covering both experimental and theoretical aspects. Dye-sensitized solid-state photovoltaic cells and nanostructured dye-sensitized photoelectrochemical cells based on composite materials are important innovations originating from the project. The work completed has given rise to nearly 160 publications in international journals. The project has gained recognition has focus of activity in this field and papers published are frequently cited.

PROJECT OUTPUT 2004:

In the year 2004, the project conducted investigations on semiconductor nano-heterostructures, semiconductor quantum dots and their utilization in solar energy conversion systems. The sensitization of nanocrystalline oxide semiconductor films with coupled anionic-cationic molecular species was examined as a means of utilizing molecular rectification to suppress recombination.

Development of a method for making quantum dots of copper (I) oxide enabled elucidation of the photocatalytic properties of this material. The collaborative project with the Department of Physics, Georgia State University, Atlanta succeeded in demonstrating the applicability of dye-sensitization for low noise near infra-red detection.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Dye-sensitized solar cells made from nanocrystalline TiO_2 films coated with outer layers of different oxide materials
   Authors: **Bandaranayake K.M.P., Seneviratne M.K.I.,** Weligamuwa P.M.G.M.P., and **Tennakone K.**
   Journal: ***Coordination Chemistry Reviews*, 248**:1277 (2004)[1,2]

2*†. *Title:* Construction of a photovoltaic device by deposition of thin films of the conducting polymer polythiocyanogen
   Authors: **Perera V.P.S., Jayaweera P.V.V., Pitigala P.K.D.D.P., Bandaranayake P.K.M.,** Hastings G., **Perera A.G.U.,** and **Tennakone K.**
   Journal: ***Synthetic Metals*, 143**: 283 (2004)[1,2]

3. *Title:* A solar cell sensitized with three different dyes
   Authors: **Perera V.P.S., Pitigala P.K.D.D.P., Seneviratne M.K.I.,** and **Tennakone K.**
   Journal: ***Solar Energy Material and Solar Cells*, 85**: 91 (2004)[1,2]

4. *Title:* Water photoreduction with Cu_2O Quantum Dots on TiO_2 Nano-Particles
   Authors: **Seneviratne M.K.I., Pitigala P.K.D.D.P.,** and **Tennakone K.**
   Journal: ***Journal of Photochemistry and Photobiology: A Chemistry***, 2004 (in press) [1,2]

5. *Title:* Photocatalysis of CFC degradation by titanium dioxide
   Authors: **Tennakone K.** and **Wijayantha K.G.U.**
   Journal: ***Applied Catalysis B: Environmental,*** 2004 (in press) [1,2]

6. † *Title:* Dye-sensitized near-infrared room temperature photovoltaic photon detectors
   Authors: **Jayaweera P.V.V., Perera A.G.U., Seneviratne M.K.I., Pitigala P.K.D.D.P.,** and **Tennakone K.**
   Journal: ***Applied Physics Letters,*** 2004 (in press)[1,2]

7. *Title:* Sensitization of Nanostructured TiO2 by Electostatic Coupling of Ionic Dyes to Ionic Absorbates
   Authors: **Pitigala P.K.D.D.P., Seneviratne M.K.I., Perera V.P.S.,** and **Tennakone K.**
   Journal: ***Langmuir*, 20**: 5100 (2004)[1,2]

8*. *Title:* Dye-sensitized Solid-state Photovoltaic Cells Based on Dye-multilayer Semiconductor Nanostructures
   Authors: **Perera V.P.S., Pitigala P.K.D.D.P., Jayaweera P.V.V., Bandaranayake K.M.P.,** and **Tennakone K.**
   Journal: ***Journal of Physical Chemistry* B, *American Chemical Society*, 107**: 13758 (2004) [1,2]

9.* *Title:* Dye-sensitize solid-state solar cells made from magnesium oxide-coated nanocrystalline titanium dioxide
Authors: **Kumara G.R.R.A., Okuya M., Murakami K., Kaneko S., Jayaweera P.V.V.,** and **Tennakone K.**
Journal: ***Journal of Photochemistry and Photobiology: A Chemistry,*** **164:** 183(2004) [1,2]

10. *Title:* Doping CuSCN Films for Enhancement of conductivity: Application in Dye-sensitized Solid-state solar cells
Authors: **Perera V.P.S., Seneviratne M.K.I., Pitigala P.K.D.D.P.,** and **Tennakone K.**
Journal: ***Solar Energy Materials and Solar Cells,*** 2004 (in press) [1,2]

11. *Title:* Dye-Multilayer semiconductor Nanostructures
Authors: **Pitigala P.K.D.D.P., Seneviratne M.K.I., Perera V.P.S.,** and **Tennakone K.**
Journal: ***Comptes Rendus Chemie,*** 2004 (in press) [1,2]

† ***This publication is included in the publication list of the project Semiconductor Optoelectronics***
* ***Reported as 'in press' in Annual Report 2003***
[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. **Pitigala P.K.D.D.P., Seneviratne M.K.I., Perera V.P.S,** and **Tennakone K.**
Dye-multylayer semiconductor Nanostructures,
Proceedings 15th International Conference on Photochemical Conversion and Storage of Solar Energy, July 2004 (Abstract)

2. Konno A., Kumara G.R.R.A., and **Tennakone K.**
The effect of TiO_2 surface coating by metal oxides or acetates and improvement of the open-circuit voltage of Dye-sensitized solid-state solar cells,
Symposium on Fundamental Science and Technology of Photofunctional Materials, 206th Meeting of the Electrochemical Society, October 2004 (Abstract)

3. Konno A., Kumara G.R.R.A., and **Tennakone K.**
Synthesis of Alkylimidazolium Thiocyanate Molten Salts and Its Application to solid-state dye-sensitized solar cells.
Symposium on Fundamental Science and Technology of Photofunctional Materials, 206th Meeting of the Electrochemical Society, October 2004 (Abstract)

INVITED LECTURES/CONFERENCES ATTENDED IN 2004:

1. **Tennakone K.**

   Dye-semiconductor Nano-Heterostructures for solar Energy conversion, *3rd Trivendrum International Symposium on Recent Trends in Photochemical Sciences, January 2004 (invited lecture)*

PROJECT : PHOTOCHEMISTRY

COMMENCEMENT : 1999

INVESTIGATORS (2004):

Bandara J., *Senior Research Fellow* **(Project Leader)**
Tennakone K., *Senior Research Professor*
Maligaspe E., *Research Assistant*
Rajapakse C.S.K., *Research Assistant*
Uthtamawadu P., *NSF funded Research Assistant*
Yasomanee S., *NSF funded Research Assistant*
Jayatilake S., *Volunteer Student*

PROGRESS ACHIEVED (*Since inception*):

Control of the structure of inorganic materials on the nanometer scale is currently attracting extensive interest. Interfacial electron-transfer dynamics are fundamental to solar cell applications and optimization of these interfacial dynamics is a key issue in achieving improvement in device performance. Control of charge recombination in dye-sensitised solar cells by means of coating of nanocrystalline oxides films with an insulating oxide was successfully demonstrated by the Photochemistry Project at IFS.

Number of Publications during 1999 - 2004 in refereed international journals: 17

PROJECT OUTPUT 2004:

The use of n-p and n-i-p junctions made of SnO_2/NiO (TiO_2/NiO) and SnO_2/MgO/NiO were investigated as a mean of enhanced charge separation for the dye-sensitized (DS) photoelectrochemical cells (PECs). Several p-type oxide semiconductors were prepared and tested for their use as hole conductors in solid-state dye-sensitiyed solar cells.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Time Evolution Studies of the H_2O/Quartz Interface Using Sum Frequency Generation, Atomic Force Microscopy and Molecular Dynamics
   Authors: Li I., **Bandara J.**, and Shultz M.J.
   Journal: ***Langmuir*, 20:** 10474 (2004)[1,2]

2. *Title:* Solid-state dye-sensitized solar cell with p-type NiO as a hole collector
   Authors: **Bandara J.** and Weerasinghe H.
   Journal: ***Solar Energy Materials and Solar Cells*** (in press) [1,2]

3. *Title:* The role of n–p junction electrodes in minimizing the charge recombination and enhancement of photocurrent and photovoltage in dye sensitized solar cells
Authors: **Bandara J.**, Pradeep U.W., and Bandara R.G.S.J
Journal: ***Journal of Photochemistry and Photobiology A: Chemistry,*** 2004 (in press) [1,2]

4.* *Title:* Fabrication of n-p junction electrodes made of n-type SnO_2 and p-type NiO for control of charge recombination in Dye sensitized Solar Cells
Authors: **Bandara J.**, Divarathne C.M., and Nanayakkara S.D.
Journal: ***Solar Energy Materials and Solar Cells*, 81(4):** 429 (2004) [1,2]

5.* *Title:* TiO_2/MgO composite photocatlyst: The role of MgO in photoinduced charge carrier separation
Authors: **Bandara J.**, Hadapangoda C., and **Jayasekera W.G.**
Journal: ***Applied Catalysis B: Environmental*, 50:** 83 (2004) [1,2]

6. *Title:* Nanoscale cavities in ionomer membrane for the formation of nanoparticles
Authors: Sun Y.P., Atorngitjawat P., Lin Y., Liu P., Pathak P., **Bandara J.**, Elgin D., and Zhang M.Z.
Journal: ***Journal of Membrane Science*, 245** (1): 211 (2004) [1,2]

7. *Title:* Enhancement of Photovoltage of Dye Sensitized Solid-state Solar cells by introducing high-band gap oxide layers
Authors: **Bandara J.** and Weerasinghe H.
Journal: ***Solar Energy Materials and Solar Cells,*** (in press) [1,2]

8. *Title:* Employing NiO as a hole collector in Solid-state dye-sensitized solar cell
Authors: **Bandara J.** and Weerasinghe H..
Journal: ***Institute of Physics Sri Lanka,*** (in press)

9. *Title:* Efficient Solid-state dye sensitized solar cells fabricated on a compact TiO_2 barrier layer preventing short-circuit current
Authors: **Bandara J.** and Weerasinghe H.
Journal: ***Institute of Physics Sri Lanka,*** (in press)

* ***Reported as 'in press' in Annual Report 2003***
[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. Weerasinghe H.C. and **Bandara J.**
   High-Efficiency Solid-state Dye-sensitized Solar Cells Using Coupled dye Mixtures
   Proceedings of the Sri Lanka Association for the Advancement of Science, 60th Annual Session, December 2004, Colombo

2. Pradeep U.W., Bandara R.G.S.J., and **Bandara J.**
   The Role of n-p Junction Electrodes in Minimizing Charge Recombinations in Dye-Sensitized Solar Cells
   Proceedings of the Sri Lanka Association for the Advancement of Science, 60th Annual Session, December 2004, Colombo

PROJECT : **SOLID STATE CHEMISTRY**
(Chemistry, preparation and characterization of semiconducting materials, conducting organic solids and polymers)

COMMENCEMENT : 1999

INVESTIGATORS (2004):

Senadeera G.K.R., *Senior Research Fellow* **(Project Leader)**
Pathirathne W.M.T.C., *Research Assistant*
De Silva N., *Research Assistant*
Fernando J.M.R.C., *NSF funded Research Assistant*
Weligamuwa P.M.G.M.P., *Volunteer Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

This Project was initiated in 1999 and deals with the investigations on the determination of fundamental physico-chemical aspects that are centered to electrically conducting polymers and conventional semiconductors, which have been the object of increasing academic and technological interest during the last 10-15 years. In these investigations materials synthesized chemically or electrochemically were characterized by (CV) cyclic voltametry, SEM, TEM, XPS, FTIR, AC impedance and photocurrent measurements.

Some of the major achievements are:

(a) The identification of complexes of Cu(I) bromide with sulfides *(Sri Lankan Patent No. 11982)* .
(b) Pentacene as promising materials suitable for positive charge collection in solid-state dye sensitized photo cells.
(c) Discovery of a new method for deposition of CuSCN on dye coated TiO_2 films and a simple model system, where the broadening of the spectral response, enhanced charge separation and the consequent increase in the energy and incident photon to current efficiencies in photoelectrochemical cells by ionic linkage of some complexes of dyes.
(d) Successfully fabricated efficient solar photovoltaic device comprising with chemically attached poly 3-thiopnenyl acetic acid as the sensitizer for several nanocrystaline semiconductors, (An international patent has been applied for this work).
(e) Construction of a fully automated spray pyrolysis unit (equipment) to prepare homogenous nanocrystalline oxide semiconducting thin films.

Total No. of articles published (since inception,1999-2004)

(a) ***In refereed journals cited in Science Citation Index: 15***
(b) ***In other refereed journals: 2***
(c) ***Abstracts and conference proceedings: 13***
(d) ***Conference proceedings full papers: 7***

(e) ***Patents : Sri Lankan Patent No. 11982, International Patent No.*** **NKS 2624-2003-36805**

(f) ***Presidential Awards for Research Publications in Science Citation Index-1999, 2000, and 2001***

PROJECT OUTPUT 2004:

In order to explore the possibilities of use of new regioreguler conducting polymers suitable in photovoltaic applications, poly(3-thiophenylacetic acid) (P3TAA) and one of it's regioregular polymer Poly(3 thiophenylacetic acid)-Poly(Hexyl thiophene) (P3TAA-PHT) were synthesized, characterized and tested their photoresponses by fabricating both the solid state and liquid electrolytic photocells comprising TiO_2 electrodes and obtained higher efficiencies than the reported devices with conducting polymers so far. In these investigations, a simple, efficient and rapid- microwave assisted method has been introduced in synthesis of P3TAA in which the total synthesis consists of esterification of 3-thiophenyl acetic acid and hydrolysis of poly (3-methyl acetate) in aqueous alkaline media.

The use of amphiphilic dyes in the performance improvement of solid-state solar devices comprising with conducting polymers were also investigated. In this context, significantly improved performances were obtained for the devices comprised with poly (3,4-ethylenedioxythiophene)(PEDOT) as a hole conductor and an amphiphilic ruthenium dye with a long alkyl chain, (Z907).

The effect of self-assembled monolayer of silane–bearing compounds (SAM) on the enhancement of the photoresponses properties of the conducting polymers were investigated for the first time. In this context, volatile solvent free quasi–solid state cells were fabricated with polyaniline covalently grafted on surface modified nanicrystalline TiO_2 substrates via $C_6H_5NHC_3H_6Si(OMe)_3$.

Patent was applied by Nippon Kayaku - NKS 2624 NIPPON KAYAKU CO.,LTD. Functional Chemical Res. Lab. Tokyo, Japan for Polymer sensitized solar cells with some thiophene derivatives (2003-36805).

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title*: Microwave assisted steps in the synthesis of poly(3-thiophenyl acetic acid)
   Author: **Senadeera G.K.R.**
   Journal: ***Current Science,*** 2004 (in press)[1,2]

2. *Title:* Utilization of conducting polymer as a sensitizer in solid-state photocells
   Authors: **Senadeera G.K.R.** and **Pathirathne W.M.T.C.**
   Journal: ***Current Science,*** **87** (3): 339 (2004)[1,2]

3. *Title:* Deposition of polyaniline via molecular self-assembly on TiO_2 and its uses as a sensitiser in solid-state solar cells
Authors: **Senadeera G.K.R.**, Kitamura T., Wada Y., and. Yanagida S.
Journal: ***Journal of Photochemistry and Photobiology A: Chemistry,*** **164**: 61(2004) [1,2]

4. *Title:* Polythiophene Sensitized TiO_2 Solar Cells
Authors: Yanagida S., **Senadeera G.K.R.**, Nakamura K., Kitamura T., and Wada Y.
Journal: ***Journal of Photochemistry and Photobiology A: Chemistry,*** **166:** 75 (2004) [1,2]

5.* *Title:* Solid State dye sensitized solar cells using in situ polymerized PEDOTs as hole conductor
Authors: Saito Y., Fukuri N., **Senadeera R.**, Kitamura T., Wada Y., and Yanagida S.
Journal: ***Electrochemistry Communications,*** **6:** 71 (2004) [1,2]

6. *Title:* Photoresponses of electrodes prepared by CuSCN with electrodeposited C_{60} on mesoporous TiO_2
Authors: **Senadeera G.K.R.** and **Perera V.P.S.**
Journal: ***Chinese Journal of Physics,*** 2004 (in press) [1,2]

7. *Title:* Spray–painted nanostructured TiO_2 electrodes for solid-state dye sensitized photocells
Author: **Senadeera G.K.R.**
Journal: ***Sri Lanka Journal of Physics,*** 2004 (in press)

8. *Title*: Improvement of the Performance of Solid-State Dye-Sensitized Solar Cells Fabricated Using Poly(3,4-ethylenedioxythiophene) and an Amphiphilic Sensitizing Dye
Authors: Norihiro F., Saito Y., Kubo W., **Senadeera R.**, Kitamura T., Wada Y., and Yanagida S.
Journal: ***Journal of The Electrochemical Society,*** **151**(10): A1745 (2004) [1,2]

9. *Title:* A new crystal structure for (BEDT-TTF)2SbF6 and some of its physical properties
Authors: **Senadeera G.K.R.** and Mori T.
Journal: ***Bulletin of Materials Science,*** 2004 (in press)[2]

* ***Reported as 'in press' in Annual Report 2003***
[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1.* **Senadeera G.K.R.** and **Pathirathne W.M.T.C.**
Solid-state photocells sensitized by polythiophene derivative: poly (3-thiophenyleacetic acid)
Proceedings of Institute of Physics, Sri Lanka, 20th Technical session, 2004 (in press)

2.* **Senadeera G.K.R.** and Yanagida S.
An efficient and rapid Microwave-assisted synthesis of poly (3 thiophenyl acetic acid) polymer and its users as a sensitizer in photocells
Proceedings of Institute of Physics, Sri Lanka, 20th Technical session, 2004 (in press)

3. **Senadeera G.K.R.**, Nakamura K., Kitamura T., Wada Y., and Yanagida S.
Fabrication of Efficient polymer-sensitized solar cells
3rd Trivandrum International Symposium on Recent Trends in Photochemical Sciences, India, January, 2004 p-03.

* Full papers.

INVITED LECTURES/CONFERENCES ATTENDED IN 2004:

1. **Senadeera G.K.R.**
3rd Trivandrum International Symposium on Recent Trends in Photochemical Sciences, India

PROJECT: **SEMICONDUCTOR OPTOELECTRONICS**

COMMENCEMENT: **2003**

INVESTIGATORS (2004):

Perera A.G.U., *Visiting Research Professor* **(Project Leader)**
Tennakone K., *Senior Research Professor*
Jayaweera P.V.V., *Research Assistant*

PROJECT OUTPUT 2004:

Georgia State University (GSU) – Institute of Fundamental Studies collaboration has been very successful during the year 2004. Two IFS junior scientists are working toward their PhDs at Georgia State University. They have finished their core coursework and will be taking their PhD qualifying exams in early January 2005. A U.S. National Science Foundation (NSF) international corporation grant was obtained for extending Solar Cell research in to infrared range and particularly for the IFS personnel support at GSU. The IFS Director, Prof. Tennakone visited GSU during the summer of 2004 to carry out research on dye sensitized optoelectronic devices again supported by the NSF international grant. A novel room temperature near infrared detector based on dye sensitized nanostructures was reported in the 13th December 2004 Applied Physics Letters journal. Another paper on noise effects on the dye sensitized semiconductor optoelectronic devices has been submitted for publication. Promising results have been obtained on extending the solar cells to be active into the infrared region and a paper will be submitted for publication soon. A GSU graduate Dr. Velautham Sivakumar has returned to Sri Lanka to join the academia and has joined IFS as a visitng scientist.

Prof. Tennakone was appointed to the GSU faculty (approved by the President of GSU and the board of Regents) as an Adjunct Professor of Physics. Prof. Perera has obtained the approval from the international advisory committee of the "Quantum Well Infrared Photon Detectors (QWIP) Workshop" to have its next workshop "QWIP 2006, in Kandy, Sri Lanka with IFS participation. A proposal was submitted to NSF for "Nanoplasmonic Terahertz Detectors", with Dr. Tennakone as a visiting researcher.

PUBLICATIONS IN REFEREED JOURNALS IN 2004

1*†. *Title:* Construction of a photovoltaic device by deposition of thin films of the conducting polymer polythiocyanogen
Authors: **Perera V.P.S., Jayaweera P.V.V., Pitigala P.K.D.D.P., Bandaranayake P.K.M.,** Hastings G., **Perera A.G.U.,** and **Tennakone K.**
Journal: ***Synthetic Metals,*** **143:** 283(2004)[1,2]

2. † *Title:* Dye-sensitized near-infrared room temperature photovoltaic photon detectors

Authors: **Jayaweera P.V.V., Perere A.G.U., Seneviratne M.K.I., Pitigala P.K.D.D.P.,** and **Tennakone K.**

Journal: ***Applied Physics Letters***, 2004 (in press) [1,2]

† ***This publication is included in the publication list of the project Condensed Matter Physics***

* ***Reported as 'in press' in Annual Report 2003***

[1] ***Listed in the Science Citation Index in 2004***

[2] ***Listed in the Science Citation Index-expanded in 2004***

PROJECT: **METAL COORDINATION CHEMISTRY**

COMMENCEMENT: 1999

INVESTIGATORS (2004):

Dias H.V.R., *Visiting Research Professor* **(Project Leader)**

PROJECT OUTPUT 2004:

Metal complexes are widely used in a variety of applications ranging from catalysis, materials chemistry to medicine. Properties of metal complexes are directly related to the nature of ligands around the metal site. Thus the development of new ligands with useful steric/electronic properties is of particular interest. Current efforts are focused on the design, synthesis and applications of nitrogen and oxygen based ligands such as tris(pyrazolyl)borates, pyrazolates, triazapentadienyl systems, and aminotroponimines. We are using these new ligands to prepare metal catalysts for small molecule activation, isolate reaction intermediates, develop transition metal containing drugs, and to control photochemical processes of metal coordination compounds.

During the past few months, we have investigated the coordination chemistry and catalytic properties of metal adducts obtained using fluorinated tris(pyrazolyl)borate and triazapentadienyl ligands. Metal ions bonded to these ligands are highly electron deficient as evident from the spectroscopic data of the carbonyl groups. We have also explored the photophysical properties of copper, silver, and gold pyrazolyl adducts. They show bright luminescence under a variety of conditions.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1.* *Title*: Fluorinated Tris(pyrazolyl)borates. Syntheses and Characterization of Sodium and Copper Complexes of [HB(3-(CF_3),5-(Ph)Pz)$_3$]

Authors: **Dias H.V.R.**and Goh T.K.H.H

Journal: ***Polyhedron (Invited Paper for Special Issue on Scorpionates),*** **23:** 273(2004)[1,2]

2. *Title:* Copper(I) Complexes of Fluorinated Triazapentadienyl Ligands: Synthesis and Characterization of [N{(C_3F_7)C(Dipp)N}$_2$]CuL (where L = $NCCH_3$, $CNBu^t$, CO; Dipp = 2,6-diisopropylphenyl)

Authors: **Dias H.V.R.** and Singh S.

Journal: ***Inorganic Chemistry,*** **43:** 5786 (2004)[1,2]

3. *Title:* Sterically Demanding Methyl Tris(pyrazolyl)borate Ligands: Synthesis and Characterization of Thallium(I) Complexes Supported by $[MeB(3\text{-}(t\text{-}Bu)Pz)_3]$ and $[MeB(3\text{-}(Mes)Pz)_3]$

Authors: **Dias H.V.R.** and Wang X.

Journal: ***Polyhedron,* 23:** 2533 (2004) [1,2]

4. *Title:* Copper(I) Complexes Supported by a Heavily Fluorinated Bis(pyrazolyl)borate: Syntheses and Characterization of $[H_2B(3,5\text{-}(CF_3)_2Pz)_2]CuL$ (Where L = PPh_3, $N{\equiv}CCH_3$, $HC{\equiv}CPh$, $H_2C{=}CHPh$) and $\{[H_2B(3,5\text{-}(CF_3)_2Pz)_2]Cu\}_2(1,5\text{-COD})$

Authors: **Dias H.V.R.**, Richey S.A, Diyabalanage H.V.K., and Thankamani, J.

Journal: ***Journal of Organometallic Chemistry,*** 2004 (in press) [1,2]

* ***Reported as 'in press' in Annual Report 2003***

[1] ***Listed in the Science Citation Index in 2004***

[2] ***Listed in the Science Citation Index-expanded in 2004***

PROJECT: **NATURAL PRODUCTS CHEMISTRY**

I. Chemistry, biological activity and structure- activity relationship studies of natural products and plant extracts of Sri Lankan flora

COMMENCEMENT: 1994

INVESTIGATORS (2004):

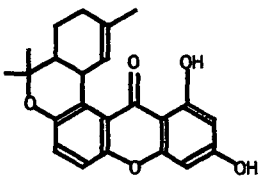
Dharmaratne H.R.W., *Associate Research Professor* **(Project Leader)**
Napagoda M.T., *Research Assistant*
Piyasena K.G.N.P., *Research Assistant*
Jayaweera D.S., *Technician*

PROGRESS ACHIEVED *(since inception)*

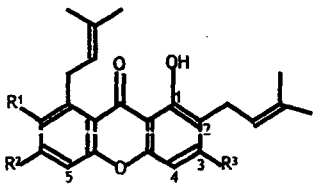
New and known prenylated xanthones isolated from *Calophyllum* and *Garcinia* species of Sri Lanka were tested for antibacterial activity, with special references to methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *Entrococci* (VRE), which are leading causes of infections in hospitals and long-term health care facilities world wide. A remarkable inhibition of *S. aureus* (MRSA and MSSA) including control *S. aureus* NCTC 6571 were observed with calozeyloxanthone(1) isolated from *C. moonii*; and γ-mangostin(2) isolated from *G. mangostana*. Their activity appeared comparable with MICs of vancomycin and gentamicin, which are presently used antibiotics to cure MRSA infections. Above two xanthones and α-mangostin(3)(MRSA activity of 3 has been previously reported) were also found to be active against vancomycin-resistant *Enterococci* (VRE) and vancomycin-sensitive *Enterococci* (VSE) with comparable MIC values with presently used antibiotics. A marked synergism between calozeyloxanthone(1) and vancomycin hydrochloride (VCM) against VRE also observed. Further our studies showed synergism between α-mangostin and gentamicin (GM) against VRE, and α-mangostin(3) and vancomycin hydrochloride (VCM) against MRSA. These finding suggest that calozeyloxanthone(1) as well as α-mangostin(3) in combination with VCM against VRE may be useful in controlling VRE infections.

Hence calozeyloxanthone(1), γ-mangostin(2) and α-mangostin(3) appears to hold promise as antimicrobial agents in the treatment of infections with *S. aureus* (MRSA and MSSA), as well as VRE and VSE. Therefore, they should be investigated further in appropriate *in-vivo* models.

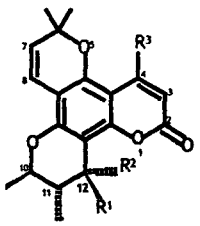
Structure-activity relationship studies of γ-mangostin(2), α-mangostin(3) and β-mangostin(4) indicated that free 3-hydoxy group in the active compounds is playing a major role in the activity of α-mangostin(3) and γ-mangostin(2).



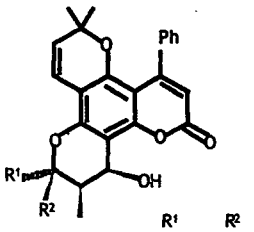
1. calozeyloxanthone



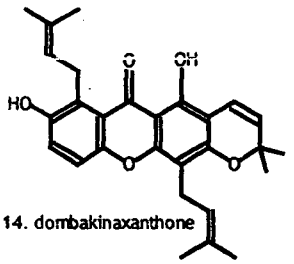
2. $R^1=R^2=R^3=$ OH, γ-mangostin
3. $R^1=OCH_3$, $R^2=R^3=$ OH, α-mangostin.
4. $R^1=R^3=OCH_3$, $R^2=$ OH, β-mangostin



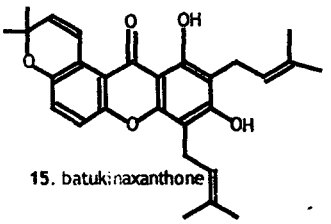
	R^1	R^2	R^3
5. calanolide A	OH	H	$-CH_2CH_2CH_3$
6. calanolide B	H	OH	$-CH_2CH_2CH_3$
7. inophyllum B	OH	H	-Ph
8. inophyllum P	H	OH	-Ph
9. cordatolide A	OH	H	$-CH_3$
10. cordatolide B	H	OH	$-CH_3$
13. cordatolide B-OMe	H	OCH_3	$-CH_3$



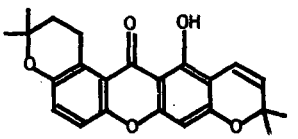
	R^1	R^2
11. soulattrolide	$-CH_3$	H
12. inophyllum A	H	$-CH_3$



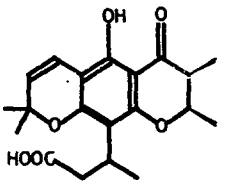
14. dombakinaxanthone



15. batukinaxanthone



16. 11, 12-dihydrothwaitesixanthone



17. isocordato-oblongic acid

Coumarins isolated from *Calophyllum* species of Sri Lanka have structural features similar to those of HIV-1 RT active compounds calanolide **A(5)**, calanolide **B(6)**, inophyllum **B(7)** and inophyllum **P(8)**, except the functionality located at C-4. In this respect cordatolide **A(9)** and cordatolide **B(10)** from *C. cordato-oblongum*, and soulattrolide(**11**) and inophyllum **A(12)** from *C. moonii* were re-isolated, and tested for anti HIV 1 RT inhibitory activity. Cordatolide **A(9)** and cordatolide **B(10)** were found to inhibit HIV-1 RT in moderate IC_{50} values. However, our experiments revealed that relative to calanolide **A(5)** and soulattrolide (**11**), activity was reduced by approximately 40-fold. Hence, current results indicated that substituent located at position C-4 is also important for the activity. Further inhibitory activity against the HIV-1 and its virally encoded reverse transcriptase (RT) were conducted using coumarins, xanthones and chromene acids isolated from different *Calophyllum* species of Sri Lanka. Except cordatolide **A(9)** and cordatolide **B(10)**, all the other

compounds were found to be inactive, indicating the necessity of the critical hetero-ring with three chiral centers at C-10, C-11 and C-12 and the free hydroxy group at position 12. Further our results suggested that the 2,2-dimethyl functionality by itself is biologically insignificant in conferring HIV-1 RT inhibitory activity. Therefore, observations based on above structure activity studies should be taken in to account when considering alternative natural or synthetic pyranocoumarin inhibitors of HIV-1 RT.

The absolute stereochemistry of cordatolide **A(9)** and cordatolide **B(10)** and soulattrolide **(11)** were proposed using Mosher's concept and molecular mechanics calculations after converting them to α -methoxy-α-(trifluromethyl)phenylacetate (MTPA) esters.

Chemical investigation of *Calophyllum cordato-oblongum, C.mooni* and *C. thwaitesii* yielded new seconadry metabolites cordatolide **B**-OMe **(13)**, dombakinaxanthone**(14)**, batukinaxanthone**(15)**, 11, 12-diydrothwaitesiixanthone**(16)** isocordato-oblongic acid**(17)** and a considerable number of previously reported compounds.

Above findings and other collaborative research work paved the way to twenty-two international publications, thirty-three research communications and following postgraduate degrees.

Wanigasekera W.M.A.P. - Chemistry and search for antiviral/anti-HIV activity of some Sri Lankan *Calophyllum* species. M. Phil, University of Peradeniya (1996).

Wijesinghe W.M.N. - Chemistry and antimicrobail activity of *Calophyllum moonii* M. Phil, University of Colombo (1999).

Marasinghe G.P.K. - Chemistry and antiviral/anti-HIV activity of family Clusiaceae. M. Phil, University of Peradeniya (2000).

As recognizance of our work, following awards have been received by members of our research group.

1. Institute of Chemistry **Gold Medal 2004,** for outstanding contribution in the use of Chemical Sciences for the development or innovation in industry or for national development in Sri Lanka. **Dharmaratne H.R.W.**

2. Visiting Scholar, National Canter for Natural Products Research University of Mississippi, University, MS, USA 2000/2001 - **Dharmaratne H.R.W.**

3. **Kandiah Memorial Award** (11) for the best piece of research carried out by a postgraduate student in Sri Lanka 1999 - **Wijesinghe W.M.N.M**

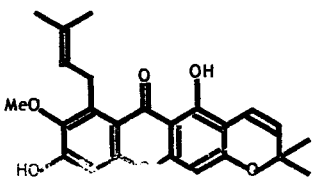
4. **Kandiah Memorial Award** (11) for the best piece of research carried out by a postgraduate student in Sri Lanka 1997 - **Wanigasekera W.M.A.P.**

5. **TWAS/NARESA award** for the best young scientist of the year 1996 (Chemistry Award) - **Wanigasekera W.M.A.P.**

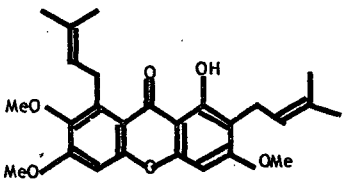
PROJECT OUTPUT 2004:

Antibacterial activity of pure compounds [α-mangostin(3) and its' cyclised product(18), β-mangostin(4), γ-mangostin (2), methoxy-β-mangostin(19) and garcinone-E(20)] and extracts from *G. mangostana*, were tested against seventeen MRSA strains isolated from hospitals in Sri Lanka and five control strains *S. aureus* (NCTC 6571), *Enterococci fecalis* (NCTC 12697), *Pseudomonas* (NCTC 10662), *Klebsiella* (Pamilo Water strain) PW and *Escherichia coli* (NCTC 10418) using a disk diffusion method. Of them other than methanol extracts of fruit hull and latex, compounds 3,2 and 18 showed activity against *S. aureus* (NCTC 6571) at MICs 1.04, 4.16 and 16.66 μg/ml respectively. Further. 2 and 3 showed activity against *E. fecalis* (NCTC 12697) at MICs 1.04 and 4.16 μg/ml respectively.

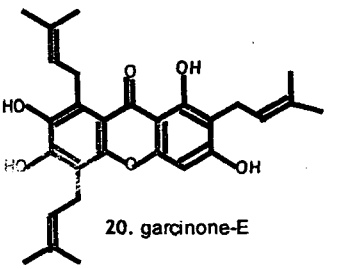
The latex of *G. mangostana* consists of more than 75% of xanthones which have strong antibacterial (anti MRSA and VRE), anti-inflammatory, antifungal and a number of other biological activities. Hence the presence of the above highly bioactive compounds in large quantities in the plant should be the causative factor for *G. mangostana*'s medicinal value in indigenous medicine. Therefore, above antibacterial compounds should be investigated further in appropriate *in vivo* models.



18.



19. methoxy-β-mangostin



20. garcinone-E

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* A Geranylated biphenyl derivative from Garcinia mangostana
   Authors: **Dharmaratne H.R.W.**, Tennakoon S.B., and **Piyasena K. G. N. P.**
   Journal: ***Natural Product Research,*** 2004 (in press)[2]

2.* *Title:* Antibacterial activity of α-Mangostin against Vancomycin Resistant *Enterococci* (VRE) and Synergism with Antibiotics.
   Authors: Sakagami Y., Iinuma M., **Piyasena K. G. N. P.**, and **Dharmaratne H.R.W**
   Journal: ***Phytomedicine,*** 2004 (in press)[2]

* ***Reported as 'in press' in Annual Report 2003***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEDINGS IN 2004:

1. **Dharmaratne H. R. W.**
   Search for Bioactive molecules from Sri Lankan flora
   Chemistry in Sri Lanka 2004, **21**-3, P 9-13.

2. **Dharmaratne H.R.W., Piyasena K.G.N.P.,** and Tennakoon S.B.
   A geranylated biphenyl derivative from Garcinia mangostana
   AFASSA regional symposium, Yahalatenna, Sri Lanka 16-18 June 2004, p29.

3. **Piyasena K.G.N.P.,** Ekanayake, E.W.M.A., Thevanesam V. and **Dharmaratne H.R.W.**
   Antibacterial Activity studies of the latex and the fruits of *Garcinia mangostana*
   Proceedings of Sri Lanka Association for the Advancement of Science, 60th annual session, 2004, 245 p.p

4. **Dharmaratne H.RW., Napagoda** M.T. and Tennakoon S.B.
   Anti-fungal activity and freeradical scavenging property of xanthones from *Calophyllum thwaitesii*
   Proceedings of Sri Lanka Association for the Advancement of Science, 60th annual session, 2004, 241 p.p

AWARDS:

1. Institute of Chemistry **Gold Medal 2004**, for outstanding contribution in the use of Chemical Sciences for the development or innovation in industry or for national development in Sri Lanka. **Dharmaratne H.R.W.**

PROJECT : **NATURAL PRODUCTS CHEMISTRY**

II. Search for bioactive compounds from Sri Lankan plants as potential resources for treatment and control of diseases

COMMENCMENT: 1992

INVESTIGATORS (2004):

Jaysinghe U.L.B., *Associate Research Professor* **(Project Leader)**
Amarasinghe N.R., *Research Assistant*
Medawala M.M.W.S., *Research Assistant*

PROGRESS ACHIVED *(since inception)*:

During the past ten years we have been doing research on various parts of following plants: *Pometia eximia* and *Filicium decipiens* (Sapindaceae), *Sarcococca brevifolia* (Buxaceae), *Uncaria elliptica* (Rubiaceae), *Terminalia catappa* (Combretaceae), *Diploclisia glaucescens* (Menispermaceae), *Bridelia retusa* ,*Ageratum conyzoides*(Euphorbiaceae) and Artocarpus nobilis (Moraceae). This work led to the isolation and structure elucidation of hederagenin saponins, quinovic acid saponins, phytolaccagenic acid saponins, serjanic acid saponins, oleanolic acid saponins, norneohopane ester of caffeic acids, flavonoid glycosides, flavone C-glycosides, steroidal alkaloids, indole alkaloids, ecdysteroids, bisabolane sesquiterpenes and phenolic compounds etc. Some of these isolates showed strong antibacterial, antifungal, molluscicidal and insecticidal activity. Further we have revised the previous structure assignments of uncaric acid, diketouncaric acid and diacetouncaric acid which were reported from *Uncaria elliptica* (Rubiaceae). In addition, we have identified a number of antifungal, antibacterial, nematicidal and antifeedant active extracts from some Sri Lankan plants.

PROJECT OUTPUT 2004:

Chemical investigation of the combined dichloromethane and the ethyl acetate extracts of the fruits of *Artocarpus nobilis* furnished five new geranylated phenolic constituents, 3'-geranyl-2',4,4'-trihydroxychalcone(**1**), 2,4,4'-trihydroxy-3'-[(*E*)-2,3-dihydroxy-3,7-dimethyloct-6-enyl]chalcone (**2**), 6-geranyl-4',5-dihydroxyflavanone (**3**), 3',4',5-trihydroxy-6-[(2*E*)-3,7-dimethylocta-2,6-dienyl)]flavone (**4**), 3'-geranyl-4',5,7-trihydroxyflavanone (**5**), together with known related compounds, xanthoangelol (**6**), xanthoangelol B (**7**), 6-geranyl-2',3',4,4'-tetrahydroxychalcone (**8**), lespeol (**9**) and isonymphaeol-B (**10**). Compounds **4**, **8** and **10** showed strong antioxidant activity against DPPH radical by spectrophotometric method.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Geranyl chalcone derivatives with antifungal and radical scavenging properties from the leaves of *Artocarpus nobilis.*
   Authors: **Jayasinghe L.**, Balasooriya B.A.I.S., Padmini W.C., and Fujimoto Y.
   Journal: ***Phytochemistry*, 65**: 1287–1290(2004)[1,2]

2. *Title:* *N*ew 3,4-*seco*-lupane derivative from *Lasianthus gardneri*
   Authors: Dallavalle S., **Jayasinghe L.**, Kumarihamy B.M.M., Merlini L., MussO L., and Scaglioni L.
   Journal: ***Journal of Natural Products*, 67**: 911-914(2004)[1,2]

3. *Title:* Steroidal and triterpenoidal saponins from the fruits of *Diploclisia glaucescens*
   Authors: **Jayasinghe U.L.B.**, Balasooriya B.A.I.S., Hara N., and Fujimoto Y.
   Journal: ***Natural Product Research,*** 2004 (in press).[2]

4.* *Title:* A fungistatic chromene from *Ageratum conyzoides Ageratum*
   Authors: **Iqbal M.C.M., Jayasinghe U.L.B.,** Herath H.M.T.B., **Wijeysekara K.B.**, and Fujimoto Y.
   Journal: ***Phytoparasitica,* 32(2)**: 119-26 (2004)[1,2]

5.* *Title:* Glycosides from *Grewia damine* and *Filicium decipiens*
   Authors: **Jayasinghe U.L.B.,** Balasooriya B.A.I.S., Bandara A.G.D., and Fujimoto Y.
   Journal: ***Natural Product Research,* 18(6):** 499 (2004)[2]

6.* *Title:* Stilbene derivatives with antifungal and radical scavenging properties from the stem bark of *Artocarpus nobilis*
   Authors: **Jayasinghe U.L.B.,** Puvanendran S., Hara N., and Fujimoto Y.
   Journal: ***Natural Product Research,* 18(6):** 571 (2004) [2]

**** Reported as 'in press' in Annual Report 2003***
[1] Listed in the Science Citation Index in 2004
[2] Listed in the Science Citation Index-expanded in 2004

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. Jayasinghe U.L.B.
Search for biologically active compounds from Sri Lankan plants
Session Lecture, 9th International Symposium on Natural Product Chemistry, 2004 January 9-13, Karachi, Pakistan.

2. **Jayasinghe U.L.B.,** Samarakoon T.B., and Kumarihamy B.M.M.
Prenylated flavonoids and xanthones with radical scavenging properties from the root bark of *Artocarpus nobilis*
Proceedings of the Peradeniya University Research Sessions, Sri Lanka. (2004) 9, 127.

3. **Jayasinghe U.L.B.** and **Amarasinghe N.R.**
Chemical constituents of *Artocarpus altilis*
Proceedings of the Peradeniya University Research Sessions, Sri Lanka. (2004) 9, 145.

4. **Jayasinghe U.L.B.** and Rupasinghe G.K.
Geranylated phenolic constituents from the fruits of *Artocarpus nobilis*
Proceedings of the Peradeniya University Research Sessions, Sri Lanka. (2004) 9, 129.

PROJECT: **BIOCHEMISTRY**

COMMENCEMENT: 1997

INVESTIGATORS (2004):

Dharmaratne H.R.W., *Associate Research Professor* **(Project Leader)**
Wanigasekera W.M.A.P., *Visiting Scientist*
Balasuriya B.M.G.K., *Research Assistant*
Fernando W.I.T., *Research Assistant*
Perera S.M., *Technician*

PROGRESS ACHIEVED *(since inception)*:

Two acid proteinases present in the juice of pitchers of *Nepenthes distillatoria* were purified to near homogeneity using DEAE cellulose chromatography, sephacryl S-200 chromatography, pepstatin-sepharose chromatography and mono Q chromatography. Partial amino terminal amino acid sequences of both proteinases were determined and compared with reported sequences of other known plant aspartic proteinases such as rice, barley and cardoon.

Antibodies to both enzymes were produced by immunizing rabbits with purified enzymes. Proteolytic action of *Nepenthes* major proteinase at different pH levels was investigated on natural proteins. Immunohistochemical staining suggested that both enzymes are produced by the cells located in the inner wall of the lower 1/3 part of the pitcher. Proteolytic action of *Nepenthes* major acid proteinase on dhal and other proteins at acidic as well as neutral pH levels were found to be remarkable. Enzymic and structural characterization of nepenthesin, a unique member of a novel subfamily of aspartic proteinases was completed.

Under the project on efficacy and toxicological studies on herbal remedies in veterinary practice in Sri Lanka, anthelmintic property of 20 crude plant extracts were assessed *in vitro* using larval migration inhibition(LMI) assay. Of them *Azadiractha indica* (neem seed), *Areca catechu*(areca-nut) unripe fruit kernel, *Adhatoda vasica* (pavatta) leaves, *Cinnamum verum* (Cinnamon)leaves and *Tamarandus indica* (siyambala) leaves caused a significant($p<0.001$)reduction in larval migration, and the degree of LMI increased significantly with the increasing concentrations of active extracts. Plant extracts with a significant anthelminitc activity were subjected to a mice toxicity study and the extracts of *A. catechu* and *A. vasica* were found to be non-toxic to mice. Therefore, above non toxic extracts were subjected to two dose titration trials, using 49 (4 - 6months old) naturally infected (eggs per gram faeces: 1000-3400), crossbred goats. The first trial was carried out using the anticipated effective dose and the second trial was carried using 2 times the anticipated effective dose. Above study showed that the crude extracts of *Areca catechu*(areca-nut) unripe fruit kernel, *Adhatoda vasica*(pavatta) leaves and *Cinnamum verum* (Cinnamon)leaves may be used to control gastrointestinal nematodiasis in goats. However, long-term prophylactic trials should be conducted before recommending their use.

Water extracts of thirty traditional greens in Sri Lanka were tested for cytotoxic activity using brine shrimp (*Artemia salina*) lethality bioassay. As anticipated most of the plant extracts did not show cytotoxic activity. On the other hand, some of the greens which are very popular among local consumers have shown significant cytotoxicity indicating the potential health risks in consuming them. Of them *Alternanthera sessilis*, locally known as Mukunuwenna/Ponankani which is very popular among the Sri Lankans, showed considerable cytotoxicity. Therefore, there is an important need for more investigations on toxicological aspects to evaluate their potential health risks to human beings. Further water extracts of *Polyscias scutellaria* (Koppa kola) and *Sauropus androgynus* (Malla) which are a less popular greens also showed cytotoxic activity. Water extract of *Alternanthera sessilis*, which had a significant cytotoxicity was subjected to a mice toxicity study and results are under investigation.

Above findings paved the way to one publication, eight research communications, a postgraduate degree and an award.

Postgraduate Degrees:

Rajapakse R.G.S.C. Purification and characterization of Acid Proteinases from *Nepenthes distillatoria* L., M. Phil, University of Peradeniya (2002).

Awards:

The abstract titled "*In vitro* anthelmintic activity of some indigenous plant extracts against caprine gastrointestinal parasites" was awarded as a Commendable presentation at the Proceedings of University of Peradeniya (2003).

PROJECT OUTPUT 2004:

Twenty crude plant extracts were evaluated for their anthelminitc activity using *in vitro* larval migration inhibition (LMI) assay. Of them,, *Azadiractha indica* (neem seed) (NS), *Areca catechu*(areca-nut) unripe fruit kernel(AUFK), *Adhatoda vasica*(pavatta) leaves (PL), *Cinnamum verum* (Cinnamum)leaves (CL) and *Tamarandus indica* (siyambala) leaves (TL) caused a significant($p<0.001$)reduction in larval migration. Since our *in vitro* tests have shown encouraging results, toxicological properties of these active extracts, were studied using Swiss mice to determine the safety margin, and thereby ensure the usage as anthhelmintics. Plant extracts with significant inhibitory activity were subjected to two dose titration trials, using 49 (4-6months old) naturally infected (egs per gram faeces; epg 1000-3400), crossbred goats. The animals were allocated randomly to 7 groups and drenched with a single dose of one of the following; levamisole(12mg/kg),AUFK(5mg/ml), PL(60mg/ml), NS (30mg/ml), CL(30mg/ml), TL(90mg/ml); other group was used as a control. Each group was treated with the corresponding extract at a dose rate of 0.2ml/kg body weight and fecal samples were collected on day -2, 0 and 10.The first trial was carried out using the anticipated effective dose and the second trial was carried using 2 times the anticipated effective dose. In the dose titration trial, the crude extracts of AUFK, PL and CL significantly (<0.05) reduced the number of worm eggs in the faeces of naturally infected goats. The fecal egg count reduction (FECR) levels were 44.4% and 43% & 36.3% respectively in the first trail and 80%,

75 % & 66.66% respectively for the second trial using a two-fold concentration. Study carried out to evaluate the anthelminitc potential showed that the crude extracts of *A. catechu*, *A. vasica* and *C. verum* may be used to control gastrointestinal nematodiasis in goats. Thus long-term prophylactic trials should be conducted before recommending their use.

Water extracts of thirty traditional greens in Sri Lanka were tested for cytotoxic activity using brine shrimp (*Artemia salina*) lethality bioassay. As anticipated most of the plant extracts did not show cytotoxic activity. On the other hand, some of the greens which are very popular among local consumers have shown significant cytotoxicity indicating the potential health risk in consuming them. Of them *Alternanthera sessilis*, locally known as Mukunuwenna/Ponankani showed considerable cytotoxicity. This herb is very popular among the Sri Lankans because of its' taste and comparatively low cost and large quantities often being consumed in a single meal. Therefore, there is an important need for more investigations on toxicological aspects to evaluate their potential health risks to human beings. Further water extracts of *Polyscias scutellaria* (Koppa kola) and *Sauropus androgynus* (Malla) which are a less popular greens also showed cytotoxic activity. These results indicate that further toxicity studies should be carried out using cell lines and *in vivo* models to investigate their potential health risks.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Enzymic and structural characterization of nepenthesin, a unique member of a novel subfamily of aspartic proteinases
   Authors: Athauda S.B.P., Matsumoto K., Rajapakshe S., Kuribayashi M., Kojima M., Kubomura-Yoshida N., Iwamatsu A., Shibata C., Inoue H., and Takahashi K.
   Journal: ***Biochemical Journal,*** **381:** 295-306 (2004)[1,2]

[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS /CONFERENCE PROCEEDINGS IN 2004:

1. **Fernando W.I.T.**, Rajapakse R.P.V.J., Fazi M.A.M., and **Dharmaratne H.R.W.** Anthelmintic efficacy of medicinal plants against gastrointestinal nematodes of goats.
   Proceedings of the Peradeniya University Research Sessions, Sri Lanka. (2004) 9, 210.

2. **Fernando W.I.T.,** Rajapakse R.P.V.J., **Dharmaratne H.R.W.**, and Ekanayeka S. Potential use of herbal anthelmintics in controlling gastrointestinal nematodes in goats
   56th Annual Convention, Sri Lanka Veterinary Association, 2004, p 14 .

3. **Dharmaratne H.R.W.** and **Balasuriya B.M.G.K.**
Cytotoxicity studies on some traditional greens consumed in Sri Lanka
Proceedings of Sri Lanka Association for the Advancement of Science, 60th annual session, 2004, 228 p.p

PROJECT: **PLANT BIOTECHNOLOGY**

COMMENCEMENT: 1988

INVESTIGATORS (2004):

Ramanayake S.M.S.D., *Senior Research Fellow* **(Project Leader)**
Kovoor A., *Honorary Research Professor*
Meemaduma V., *Research Assistant*
Jayasekera H., *Research Assistant*

PROGRESS ACHIEVED *(since inception)*:

Problems associated with the recalcitrance to in vitro responses in selected woody perennials were investigated.
Bamboo: These belong to the family of grasses. However, unlike other grasses they are woody although different from other woody trees. Unlike other flowering plants their flowering and seeding rhythm are unpredictable and some flower after long intervals of many years. With all these unorthodox characteristics they are valuable. The objective of this project is to use tissue culture techniques to investigate the unique behavior in bamboos, develop protocols for propagule production and taxonomically identify different Sri Lankan species.

Different plant parts from field grown clumps of the two species, *Dendrocalamus giganteus* and *Bambusa vulgaris* were used to study their responses to in vitro manipulations. The phenology and development of selected clumps of these species were studied to correlate the in vitro responses of plant parts of mother clumps with developmental stages and phenology.

The axillary buds of *B. vulgaris* proliferated but it was not possible to attain continuous and rapid proliferation. Some factors responsible for the recalcitrance in this species were identified.

Plantlets were produced from seedling explants that responded to axillary shoot proliferation in the species *D. giganteus* (M. C. Rajapakse, M.Phil. thesis) and in *D. asper*.

The axillary shoot proliferation for plantlet production with the use of explants from 6 – year old and a 70-year old field grown clumps of *D. giganteus* was achieved. In vitro flowering was also induced in these axillary shoots. The factors that may have contributed to in vitro flowering were studied. The problems that have led to recalcitrance in rhizogenesis in *D.giganteus* were identified This enabled improving rooting and acclimatization of continuously proliferating shoots of two more species *D. hookeri* and *B. vulgaris*. These protocols could be now used in commercial applications. We have given away over 1500 plantlets, which were produced during experiments in these three species. The field performance of these plants can now be monitored.

Callus, which exhibited an embryogenic potential, was also induced from explants of the adult clump of D.giganteus. It was possible to regenerate a few plantlets. Although seedlings are reported to respond to such behaviour in vitro, this is the first time an adult bamboo of over 70-years behaved in this manner.

Axillary shoots of *Bambusa atra* were proliferated and flowering induced. Causes of flowering are under investigation. Rooting of the axillary shoots yielded plantlets that were acclimatized to field conditions. This could be used for large-scale plantlet production in this species.

Total DNA from 130 individuals of *D. giganteus* was extracted and RAPDs were performed with six selected primers. DNA from 25 species was extracted for a study in identification and characterization of species. Genetic distances computed and dendrograms developed using the RAPD markers that were generated. RAPD markers were also generated from DNA extracted from 25 related species of bamboo. The data have been partially analyzed and will be used in identification and characterization of species. Most of these Sri Lankan species have not been taxonomically defined.

Melocanna baccifera, a bamboo introduced from India, in the Botanic gardens, Peradeniya flowered in synchrony with the impended flowering of this species in Mizoram India. The event was used to study the flowering behaviour and taxonomy of this species.

The species *Mormodica dioica* (thumbakarawila) was used in studying callogenesis and regeneration of shoots. This is a perennial climber that responded well to plant regeneration from callus unlike bamboo and therefore possibly be utilized in studies in bamboo.

Rattan: In vitro requirements for a high germination percentage of excised embryos of four species of rattan, *Calamus zeylanicus, C. ovoideus, C. rotang* and *C. thwaitesii* were determined. It was also possible to induce multiple shoots in all four species. *C. zeylanicus* and *C. thwaitesii* showed rapid and continuous shoot proliferation while it was slow in the other two species. The origin of these shoots was studied. Root induction in the proliferated shoots of *C. thwaitesii* was possible and plants have been established in the nursery. The rooting response of *C. zeylanicus* was slow and sufficient plant were not available to carry out rooting experiments in these species due to accidental contamination of cultures. Excised embryos of *Calamus thwaitesii* and *C. rotang* were cultured to study their responses under limited growth conditions either in encapsulated form or as naked embryos.
The study on bamboo and rattan received funding from NORAD for the period October 1993 – May 1994 (Rs. 160, 000/-) and from May 1994 – October 1997 (Rs 1,406,650/-). These funds were utilized to purchase chemicals and for purchase of equipment and improving the laboratories.

In vitro micrografting and compatibility studies: This study was suspended in 1994 and revived in 1997. Culture conditions for the establishment of in vitro cultures required for grafting were determined for selected species, *Anacardium occidentale, A.microcarpum, Garcinia mangostana, Pentadesma butyracea, Durio zebethius* and *Adansonia digitata.* A technique of in vitro micrografting cashew was determined. It was also possible to achieve multiple shoot proliferation and rooting of cashew and

establishment of plantlets in the nursery. After revival of this study in 1997 seeds of *Loranthus* were cultured in vitro for inducing germination but complete plant development did not take place. Mangosteen seeds were induced to produce multiple shoots. Seeds of *Feronia, Citrus, Adansonia digitata* and *Camellia sinensis* were germinated in vitro. Various plant parts of these in vitro plantlets as well as from field grown plants *of Pentadesma* and *Loranthus* were cultured to induce callus that will be used to study the compatibility between selected scion and root stock species.

PROJECT OUTPUT 2004:

I was released to the Mahaweli Authority Sri Lanka (MASL) on their request, from 15th February 2004 for one year, to establish a laboratory and carry out the micropropagation of giant bamboo and other bamboo species of commercial value. However, the MASL could not provide the promised funds to establish the required facilities for micropropagating bamboo. I was able to design the laboratory and install some of the equipment that were available after refurbishing a building provided for this purpose by the MASL. Several meetings were held to popularize bamboo among the public according to the terms of the contract undertaken. Although my research work was interrupted during this time I managed to supervise an undergraduate student who undertook studies on bamboo at the IFS. Some bamboo cultures were maintained in the IFS in the event that they will be transferred to the MASL once the proposed lab was established.

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. **Ramanayake S.M.S.D.** and **Meemaduma V.N.**
   Exposure of axillary shoots to TDZ improves root induction and acclimatization during in vitro propagation of bamboo (*Dendrocalamus hookeri*). **In:** (Eds. Singh H. P. and Dadlani N.K.) Abstracts, *VII*th *World Bamboo Congress, 27th February – 4th March 2004, New Delhi, India.*

2. **Ramanayake S.M.S.D.**
   Micropropagation of Bamboo. Presented at the Seminar on 'Production and Utilization of Bamboo in Sri Lanka'
   Network for Bamboo and Rattan and the Sri Lanka Association for the Advancement of Science, 24th August, Colombo.

OTHER CONTRIBUTIONS:

Dissertation by undergraduate student under my supervision:
Abayagunawardene A.G.N.I. Characterization and micropropagation of four bamboo species, *Bambusa vulgaris* var. *vittata, B. ventricosa, Dendrocalamus asper* and *Gigantocloa atroviolacea.* Submitted in partial fulfillment of the B.Sc. (Agri) degree 2004, Department of Crop Science, Faculty of Agriculture, University of Peradeniya.

PROJECT: PLANT REPRODUCTIVE BIOLOGY

COMMENCEMENT: 1997

INVESTIGATORS (2004):

Iqbal M.C.M., *Senior Research Fellow* **(Project Leader)**
Kovoor A., *Honorary Research Professor*
Wijesekara K.B., *Research Assistant*
Wijesekera T.P., *Research Assistant*
Hapukotuwa R.B., *Work Assistant*

PROGRESS ACHIEVED *(Since inception):*

Pollen development, androgenesis and embryogenesis:
Androgenesis: Since establishing the experimental conditions for androgenesis in *Datura metel,* the role of a temperature shock was investigated in the induction process. In other species, temperature shock is imposed on the anthers or microspores for a few days using either a warm (30° – 35° C) or cool (4° – 20° C) temperature. We found a combination of warm and cool temperatures in quick succession, for a total duration of 1 min, significantly enhanced androgenesis.

Pollen development: In our studies on pollen development in angiosperms we encountered an unusual development of parenchyma cells in the connective tissue of anthers in *Gordonia* species. These cells developed into large pollen like cells with a distinct surface architecture and migrated into the pollen sacs. These apparent pseudopollen were sterile and their role in reproductive biology remains speculative. They have been reported in some members of the Theaceae family.

Embryogenesis: The body organization of angiosperm seedlings was studied using haploid embryos of *D. metel.* The basic embryo pattern (shoot apical meristem, cotyledons, hypocotyl, root apical meristem) is controlled by specific genes during embryogenesis whose deletion is achieved by induced mutations. We observed these deletion patterns in haploid embryos, which were characterized histologically.

Secondary embryogenesis:
The role of apical meristems in controlling secondary embryogenesis in androgenic embryos of *D. metel* was determined by excising he meristems under in vitro conditions. We observed secondary embryogenesis following meristem excision on the embryos.

Indica rice (*Oryza sativa*) is generally recalcitrant to tissue culture, which is a barrier to biotechnological improvement of rice in Asia. We screened Sri Lankan rice varieties for their ability to induce callus and regenerate plants. The indigenous genotypes showed a better response than improved varieties in preliminary investigations.

Secondary metabolism in vitro (in collaboration with Dr. C. Möllers, University of Göttingen): Glucosinolates, a secondary metabolite, is accumulated in the seeds of Brassica species duration plant maturation. Glucosinolates were transported against a concentration gradient into the embryos and was an active process.

PROJECT OUTPUT 2004:

Secondary embryogenesis: The role of apical meristem in embryos determining the embryogenic competency of cells on the embryo hypocotyl was determined. In androgenic embryos of *Datura metel*, excision of meristems induced somatic embryogenesis.
The in vitro conditions for the propagation of two aquatic plants, *Cryptocorine wendtii* and *Echinodorus cordifolius*, was determined. These plants are important in the aquaculture industry in Sri Lanka. They are indiscriminately harvested from the wild, due to lack of rapid propagation methods.

Secondary metabolism in *Adenanthera pavonina* were determined in collaboration with Dr. Zarnowski in Poland. Lipid emulsions were formulated from he oil which indicate a potential use in pharmaceutical and medical fields as carriers for active ingredients of drugs and cosmetics.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* The oil of *Adenanthera pavonina* L. seeds and its emulsions
   Authors: Zarnowski R., Jaromin A., Certik M., Czabany T., Fontaine J., Jakubik T., **Iqbal M.C.M.**, Grandmougin-Ferjani A., Kozubek A., and Pietr S.J.
   Journal: ***Zeitschrift für Naturforschung*, 59c:** 321-326 (2004)[1,2]

2.* *Title:* A fungistatic chromene from *Ageratum conyzoides*
   Authors: **Iqbal M.C.M., Jayasinghe U.L.B.**, Herath H.M.T.B., **Wijesekara K.B.**, and Fujimoto Y.
   Journal: ***Phytoparasitica* 32(2):** 119-126 (2004)[1,2]

* ***Reported as 'in press' in Annual Report 2003***
[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. Weerakoon S.R., **Iqbal M.C.M.**, and Pieris K.
   Transfer of value added traits and agronomic characters from *Brassica napus* to *Brassica juncea* by conventional crossing
   Annual Academic Sessions 2004, The Open University of Sri Lanka.

2. **Wijesekara K.B.** and **Iqbal M.C.M.**
Response of androgenic and zygotic embryos of *Datura metel* L. to excision of their meristems
Proceedings of Sri Lanka association for the advancement of science, Part I. 60 annual session, 2004. Sri Lanka association for the advancement of science, Colombo.

POSTGRADUATE DEGREES COMPLETED IN 2004:

1. *Name:* Dissanayake, W.A.D.C.P.
Thesis title: Tissue culture propagation of ornamental aquatic plants, *Cryptocorine wendtii* (wendi brown) and *Echinodorus cordifolius* (marble queen)
Degree: M.Sc Degree

Degree awarded by the University of Kelaniya, Sri Lanka, 2004

PROJECT: **PLANT CELL BIOLOGY**

COMMENCEMENT: 2001

INVESTIGATORS (2004):

Jeyanandarajah P., *Research Fellow* **(Project Leader)**
Kovoor A., *Honorary Research Professor*
Colonne P.M., *Research Assistant*

Scope of the project:

- Isolation and identification of cyanaobacteria to ascertain their biodiversity; investigation of the biological activities terrestrial and aquatic cyanobacterial forms.
- Development of assays for water-borne toxicants; identification of microorganisms capable of degrading toxins; characterisation of microbes present in biofilms in aquatic systems.
- Study of aspects of mycotrophy and formulation of methodologies for the introduction of microorganisms, including mycorrhizal fungi, for optimization of plant growth.
- Investigation of mechanism of antagonism, synergism and toxicity of rhizoplane and spermoplane microorganisms.

PROGRESS ACHIEVED *(since inception)*:

Phytoplankton: Several members of Chlorophyceae, Cyanophyceae and Bacillariophyceae were detected in the samples collected from fresh water expanses/bodies. Flow cytometer measurements made at the Alfred Wegener Institute, Brenerhaven confirmed the presence of *Chaetoceros radicans*, species of *Chroomonas* and *Emiliana* in seawater samples.

Genomic DNA was extracted from selected isolates using celite and proteinase K. Amplification was done using forward primers either Cya 106F or Cya 359F and reverse primers Cya 781a and Cya 781b. Agarose gel electrophoresis of the PCR amplified product of onee of the isolate produced clear band between 400 – 500 bp.

Investigations on surfaces of different substrates submerged at a depth of 1.5m in the Kandy Lake revealed the presence of chlorophytes and cyanophytes attached to the substrates.
Biomass of microorganisms was determined by chlorophyll a quantification and samples were prepared for the determination of secondary metabolites.

Mycotrophy: The soil samples from the wet zone with tea plantation and leafy vegetable plots gave positive results with different types of spores of endogonaceous mycorrhizal fungi being present.

Rhizoplane and rhizosphere fungi were isolated from samples collected from leafy vegetable plots. Fungi were also isolated from leaves of the crops in these plots.

PROJECT OUTPUT 2004:

Phytoplankton:

- Toxigenic cyanobacteria were detected in the samples collected from lakes. The Beira Lake, a prominent landmark of Colombo, which has periodically posed environmental related problems, was investigated in this study. Bloom-forming microbes were observed and samples were collected from the surface and at different depths. The microorganism prevalent in the surface scum and water were species of *Microcystis*. Studies were undertaken to identify and quantify the toxic compounds present in the water and the cells in the scum. The techniques employed included freeze drying/air drying followed by resuspension in phosphate buffered saline (PBS); concentration by boiling; passage of filtered water through acetonitrile or methanol activated C-18 reverse-phased column followed by methanol elution of toxin, drying and resolution in PBS. Techniques using thin layer chromatography (TLC) and high performance liquid chromatography (HPLC) were employed for separation and identification of toxins. Microcystin-LR, known to be heptatoxic cyclic heptapeptide, was detected in the samples of surface water and cells of the scum. The authentic sample used was from EMD Bioscience.

Mycotrophy:

- A fungus was isolated from snakegourd (*Trichosanthes cucumerina*) by plating plant tissue onto potato dextrose agar (PDA) medium. On PDA, the mycelium was olivaceous green and few pycnidia were observed. Pycnospores were hyaline, cylindrical with rounded ends, mostly nonseptate but a few single-septate. Based on the morphological characteristics, the fungus was identified as *Didymella bryoniae*. Three isolates from different locations were studied further. The growth *in vitro* on different media PDA, potato carrot agar (PCA), snakegourd agar (SGA) and Czapek Dox agar (CzDA)), at different pH levels and temperatures were studied. In SGA medium, all three isolates produced white aerial mycelium, few pycnidia and growth, though scanty,was in regular concentric circles. Two isolates showed a similar pattern on PCA and PDA. The third isolate produced grey irregular colonies on bothe PCA and PDA; also on CzDA. The rates of growth of all three isolates were highest in PDA and lowest in CzDA. When cultured on PDA with pH adjusted to 6, 7 and 8, all the isolates had similar growth pattern. However, they differed in their rate of growth. When incubated at various temperatures on PDA, growth was maximal at 25°C and negligible at 40°C. The isolates exhibit variability in their culture characteristics.

- Phylloplane fungi were isolated from leafy vegetables by plating leaf tissues onto PDA. Fungi identified are *Alternaria alternata, Aspergillus flavus, Aspergillus niger, Cladosporium cladosporioides, Fusarium pallidoroseum, Fusarium solani, Fusarium equiseti, Myrothecium roridum, Myrothecium verrucaria, Penicillium spp., Rhizoctonia solani, and Trichoderma spp.*. Six

isolates are yet to be identified. Studies were undertaken to analyse the mycotoxins produced by some of the fungi isolated in this study. When cultured on PDA, growth of *M. roridum* and *M. verrucaria* was rapid often in concentric rings. The growth rate varied among isolates. The temperature range favourable for growth appears to be between 25°C and 30°C. The isolates were grown in static potato broth. The culture filtrates were used for biological and biochemical analysis. Symptoms of vein clearing, veinal necrosis and water-soaked lesions were induced when cur shoots were held dipping in culture filtrates. Severity of the symptoms varied with the isolates. Studies related to the identification and quantification of the toxic secondary metabolites are underway.

- Isolations from the rhizosphere samples of leafy vegetable plot were done by dilution plate methods and wet sieving methods. The following fungi were detected in dilution plate method: *Alternaria tenuis, Aspergillus* spp., *Chaetomium globossum, Cldosporium* sp., *Fusarium solani, Fusarium oxysporum, Mucor* sp., *Penicillium* spp., *Rhizopus stolonifer, Sordaria fimicola* and *Trichoderma* spp. Wet sieving revealed the presence of species of *Glomus* and *Gigaspora* in plots where *Centella asiatica* was growing.

- In dual culture studies, isolate TPJ5' showed prominent antagonistic properties against a number of fungi.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Rice diseases – Problems and progress
   Authors: Seneviratne S. N. de S. and **Jeyanandarajah P.**
   Journal: ***Tropical Agricultural Research and Extension***, 2004(in press)

PROJECT: BIOLOGICAL NITROGEN FIXATION

COMMENCEMENT: 1986

INVESTIGATORS (2004):

Seneviratne G., *Senior Research Fellow* **(Project Leader)**
Indrasena I.K., *Research Assistant*
Ratnayake R., *Research Assistant*
Sepalika J.A.H., *Research Assistant*
Karunaratne R.C.K., *Technician*
Karunadasa K.K., *Work Assistant*

PROGRESS ACHIEVED (*Since inception)*:

The original aim of the project was to improve livelihood of rural Sri Lankan farmers through improved soil fertility by biological nitrogen fixation and balanced nutrient application. A variety of research programs were conducted during this period. However, present objective is to conduct basic research on biological nitrogen fixation and related topics.

a) A *rhizobium* inoculant (bacterial fertilizer) was produced for grain legumes and leguminous trees, based on a substrate made of a special mixture of organic waste materials. The inoculant could increase soybean yield by at least 26%, even up to over 100% under different soil conditions in the dry zone of Sri Lanka. A similar inoculant increased plant growth of *Albizia,* a nitrogen fixing leguminous tree by 84% on tea estates. This inoculant is now used for grain legumes in Sri Lanka, and is also being tested in Bangladesh.

b) Thirteen leaf isozymes were assessed by gel electrophoresis for identification of elite trees in a heterogeneous population of *Pericopsis mooniana* (Nadun). Such an identification is important in efficient management of reforestation programmes with slow growing, high quality timber species like the tree under consideration. Out of the isozymes tested, formate dehydrogenate showed promising results.

c) Foliar application of chelated micronutrients to rice and tea showed potential for increasing their yields. A mixture of micronutrients when applied to farmers' fields in the dry zone increased panicle and grain formation of rice by 25% and 32%, respectively. Hundred seed weight was increased by 18%. The same mixtures increased tea yields by about 30% in tea estates over a year with a net extra benefit of around 30,000 Rs/ha.

d) Polyphenols are known as disinfectants and act as bactericides. Soil polyphenols therefore affect the growth and activity of rhizobia in soils, threatening their survival. In a study of polyphenolic inhibition of rhizobia, a method for fractionation and identification of polyphenols in soils was

developed using One Dimensional Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (1 D SDS PAGE), with urea and SDS as denaturing agents.

e) Interactions between phenolic compounds and rhizobia, and the effect of phenolic acid affected rhizobia on rhizobial-legume symbiosis were studied. Phenolic acids were found to be possible agents of modifying N_2 fixing symbiosis through rhizobial alteration. A paper was published.

f) Studies on litter turnover in ecosystems led to discover that soil surface mulch application mitigates soil N_2O emission. This was published and established now. Underlying mechanisms of this mitigation were also identified.

g) A study on rhizobial-fungal biofilms was completed, where the effects of the biofilm formation on the survival and effectiveness of rhizobia under adverse conditions were examined. The biofilms were successfully developed *in vitro*, observed and reported in a research paper. This is the first observation of such biofilms.

Number of Publications in Refereed Journals: 19

PROJECT OUTPUT 2004:

1. Different biofilms were developed for various applications. A rhizobial-fungal biofilm was developed for rock phosphate solubilization. A *Pseudomonas* spp.-*Pleurotus* spp. biofilm was formed for the transfer of *Pseudomonas fluorescens* to tomato plant tissues. A *Bacillus* spp.-*Penicillium* spp. biofilm was formulated to degrade polythene biologically. Biological nitrogen fixation in mushrooms was tested and understood.

2. Soil organic matter decomposition was studied under different land-use patterns of Sri Lanka. Soils were collected and analyzed for a number of soil parameters and soil respiration, CH_4 and N_2O emissions. Soil organic carbon contents of the land-use patterns were predicted using artificial neural network (ANN) analysis and a manuscript is under revision for publication.

3. An experiment was conducted to examine soil carbohydrate controls on nutrient dynamics. Soil samples were collected from different agroclimetic zones of the country. They were analysed for basic soil parameters and macro and micronutrients. Soil extracts are now being analysed for carbohydrates using gas chromatography. A manuscript is being prepared for submission to a journal.

4. Studies were conducted to examine associative nitrogen fixation in the rice rhizosphere, with special reference to *Azorhizobium caulinodans*, an efficient nitrogen fixer in the rhizosphere. The effect of *A. caulinodans* as a monoculture on rice was evaluated and found that there is no significant effect on growth etc. Studies are now being carried on to examine its effect when it is in microbial communities or biofilms.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1.* *Title:* Isotope/element fractionation during surface adsorption
Authors: **Seneviratne G.** and **Nanayakkara A.**
Journal: ***American Journal of Physics,*** **72:** 73 (2004)[1,2]

2. *Title:* Can mushrooms fix atmospheric nitrogen?
Authors: **Jayasinghearachchi H.S.** and **Seneviratne G.**
Journal: ***Journal of Biosciences,*** **29:** 293 (2004)[1,2]

3. *Title:* A bradyrhizobial-*Penicillium* spp. biofilm with nitrogenase activity improves N_2 fixing symbiosis of soybean
Authors: **Jayasinghearachchi H.S.** and **Seneviratne G.**
Journal: ***Biology and Fertility of Soils,*** **40:** 432 (2004)[1,2]

* ***Reported as 'in press' in Annual Report 2003***
[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. **Seneviratne G., Ratnayake R.,** and Kulasooriya S.A.
Association of soil nutrients with organic matter and clay in different land use patterns of Sri Lanka
Proceedings of the Sri Lanka Association for the Advancement of Science, 2003.

POST-GRADUATE DEGREES COMPLETED IN 2004:

1. *Name:* Jayasinghearachchi H.S.
Thesis Title: Rhizobial – fungal – Phenolic interactions in Nitrogen fixing symbiosis
Degree: PhD.
Degree awarded by the University of Peradeniya, Sri Lanka.

INVITED LECTURES/CONFERENCES ATTENDED 2004:

1. Seneviratne G.
Participated in the Soils and Hydrology Workshop at the Smithsonian Tropical Research Institute, Republic of Panama, 1-8 June 2004.

PROJECT: **PRIMATE BIOLOGY**

COMMENCEMENT: 1983

INVESTIGATORS:

Dittus W., *Visiting Scientist* **(Project Leader)**

PROGRESS ACHIEVED *(Since inception)*:

The overall aim of the program is to establish new knowledge concerning the biological foundations for social behaviour in non-human primates (and by inference, man). This aim has interdisciplinary ramifications. Hence, past research and publications have addressed the interrelationships among factors concerning social organization, matrilineal kinship, ecology, environmental change and their effects on demography (Darwinian fitness). For example, our research was the first to establish an actuarial life-table for primates and showed that social behaviour influences individual differences in survival, breeding success, and morphological development. Our aims and data collection protocols require consistency over many years.

In practice, to investigate such phenomena we have identified more than three thousand macaque individuals (living plus dead), distributed among 34 different social groups at our dry evergreen forest study site, at Polonnaruwa. For each macaque, we have traced its behavioural, genealogical, ecological and demographic history. Such large samples are required to assure statistical soundness.

It was not clear by which physiological and similar mechanisms behaviour affected mortality. Therefore, the research was expanded (with the aid of collaborators from a variety of institutions) to investigate the potential role of disease (parasitism) and physiology (milk composition, hormone levels) in relation to behaviour and demography. Different aspects of physiology and disease have been more intensively investigated in the primates at Polonnaruwa particularly in association with of the Faculty of Veterinary Medicine, University of Peradeniya. In addition, we have assumed a greater role in aspects of nature conservation.

PROJECT OUTPUT 2004:

(a) ***Routine demographic, ecological and behavioral monitoring.*** The entire population of over 1,100 identified macaques was censused on a monthly basis. New recruits (newborns & immigrants) were identified. The hierarchical relationships within groups was tested and documented. Intergroup relations, shifts in ranging pattern, and diets were recorded.

(b) ***Ecology of three sympatric primates.*** On a regular monthly schedule we sampled the diets, home ranges and interspecific interactions among the toque macaque, and the two langur species *Semnopithecus entellus* and *S. vetulus*. The aim of this study is to clarify the ecological relations that allow these three potentially competing species

to co-exist in sympatry. Our research protocols were modified in order to document variation in the diet of these species in relation to differences in habitat and seasons.

(c) ***Parasitism.*** We have identified the disease cryptosporidium and cyclospora for the first time in a primate of Sri Lanka. Ecological and life history data indicate that the disease is contracted by wild primates probably from feces of cattle and /or humans.

(d) ***Hematology***. Data amylases concerning haematological factors in wild toque macaques at Polonnaruwa were carried out but not completed by T. Herath of the Veterinary Faculty, University of Peradeniya.

(e) ***Professional activities:*** (i) In my capacity as Associate Editor for the American Journal of Primatology, I managed the peer review of several submitted manuscripts. (ii). I facilitated collaborative research on captive elephants between the Smithsonian Institution, the Pinnawala Elephant Orphanage and the University of Peradeniya. (iii) (iv) I guided the undergraduate thesis research of students from the Open University of Sri Lanka. (v) I conducted a workshop concerning behavioural studies for primates for students of the Department of Sociology and Anthropology at the Sri Jayewardenepura University. (vi) Did lecture and field trip for ecology students of University of Insbruck.

(f) ***Nature Conservation***: (i) I participated in meetings as a member of the National Species Advisory Group to the Ministry of Environment and Natural Resources. (iii) We donated binoculars, posters, and reading material to two local schools (Nikawewa and Lakshauyana) at Polonnaruwa in collaboration with HSBC bank. (iv) We developed conservation of the Green Belt forest at the Polonnaruwa Samudra with participation of local government bodies and schools at Polonnaruwa. (v) We organized and conducted 14 environmental education programs for local schools at Polonnaruwa and elsewhere (e.g., Trinity).

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Seroprevalence of *Toxoplasma gondii* in Wild Toque Macaques (*Macaca sinica*) at Polonnaruwa, Sri Lanka
   Authors: Ekanayake D.K., Rajapakse R.P.V.J., Dubey J.P., and **Dittus W.P.J.**
   Journal: ***Journal of Parasitology*, 90(4):** 870-871 (2004)[1,2]

[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. Ekanayake D.K., Rajapakse R.P.V.J., Rajapaksha W.R.A.K.J.S., and **Dittus W.P.J.** Sri Lanka. Detection of apicomplexan infection among *Toxoplasma gondii* seropositive monkey carcasses from Polonnaruwa, Sri Lanka. *56th Annual Convention of the Sri Lanka Veterinary association -2004. 23pp*

BOOKS AND MONOGRAPHS 2004:

1. *Title:* Demography: a window to social evolution
In the book: Macaque Societies: Model for the Study of Social Organization Pp 87-116.
Author: **Dittus W.P.J.**
Editors: Thierry B., Singh M., and Kaumanns W.
Publisher: Cambridge University Press: Cambridge.

PROJECT: **ECOLOGY AND ENVIRONMENTAL BIOLOGY**

COMMENCEMENT: 1989

INVESTIGATORS(2004):

Silva E.I.L., *Associate Research Professor* **(Project Leader)**
Karunathilake K.M.B.C., *Research Assistant*
Sharaff F.F., *Research Assistant*
Weerasinhe W.M.D, *Research Assistant*
Thumpela I., *Technician*
Athukorale N., *Technician*

PROGRESS ACHIEVED *(Since inception)*:

The project initiated as Ecology and Conservation in 1989, was renamed in 1992 as Ecosystem Analysis and Impact Assessment. The name was changed again in 1996 as Ecology and Environmental Biology with a view to restructuring the studies towards fundamental aspects of ecological studies in aquatic science. Although this project is broadly named as Ecology and Environmental Biology with an intention of future expansion, studies were primarily focused on aquatic environment with special emphasis on aquatic ecology of inland and coastal marine ecosystems.

At the beginning, a study was carried out on the limnological aspects and the fisheries of the Mahaweli river basin since 1989 with special emphasis on colonization of exotic fish species in the Victoria Reservoir, water chemistry of the Nilambe Oya, nutrient loading into Kotmale Reservoir, trophic characteristics reservoirs in the Mahaweli basin. Limnology and water quality of the Kandalama tank were studied during pre-construction, construction and operational phases of the hotel complex to determine whether it has effects on ecosystem processes and functions of the tank environment. A study was also carried out to determine the rainwater chemistry and buffer intensities of surface water in Sri Lanka. Further, commercially important fresh water fish species were analyzed for bio-accumulation of trace elements while several species of pelagic blood fishes were analyzed for the levels of histamine. A study was also launched to determine the impact of operational activities of shrimp farms in the north western province on brackish water ecosystem including Mundel Lake. In 1995, an intensive study was carried out to determine the levels of organic and inorganic pollution along course of the Meda Ela in Kandy.

Towards the end of 1996, a systemic limnological study was launched in the Kandy Lake with view to identifying the eutrophic process of a tropical urban water body. This study was intensified from May 1999, with the emergence of a cyanobacteria bloom (*Microcystis aeruginosa*) in Kandy Lake. A parallel study was also started in the Hulu Ganga, the major tributary of the Mahaweli River in the central Mahaweli Valley to determine the ecological processes and functioning of a tropical stream draining and intensively exploited watershed. A broad limnological study was

commenced in August 1998 to compare the primary productivity and nutrient dynamics of three morphologically and functionally different reservoirs namely Victoria, Minneriya and Udawalawe. This was a component of the research project of the research project launched to determine the ecological processes and dynamics of Asian reservoirs and lakes funded by the European Union. In addition, studies were conducted on retention of silica behind the dams of Sri Lankan reservoirs, which is currently being considered as an important issue of land-ocean nutrient fluxes. In 2003, detail studies on material fluxes in three adjacent river basins namely Maha Oya, Deduru Oya and Mi Oya was carried out. This study was extended to Kala Oya, Malwathu Oya and Mahaweli basins. Intensive investigations on Kandy Lake was conducted on daily basis from August to December, 2003. Studies conducted on Rekawa lagoon under European Union funded project on Mangrove Resilience in Coastal Zones in East India and Southwest Sri Lanka were completed for a period of two years. Investigation on nutrient loading into the Kandy Lake via perennial and seasonal inflows was commenced in January 2004 while Heen Ganga which drains the northeast slope of the Knuckles Range was examined monthly to determine aspects of its ecology since May 2004. An intensive survey was conducted during August-September 2004 on phytoplankton systematic in 34 major reservoirs in Sri Lanka. The results of the above studies that are ecologically significant and scientifically important were published in refereed journals and monographs and in the proceedings of local, regional and international meetings.

PROJECT OUTPUT 2004:

Major emphasis was paid on preparation of several manuscripts during the year 2004. Two papers submitted to Asian Journal of Water, Environment and Pollution were appeared in the Journal in October. Further, two papers appeared in Sri Lanka Journal of Aquatic Sciences and also one paper in Asian Fisheries Science. In addition papers were presented at five international meetings held in New Delhi, Colombo, Hanoi and Purwerkato. I was invited by ZMT Bremen to deliver a lecture on Phytoplankton in tropical Asia during the Summer School organized by the Jendral Soederman University, Purwerkato in Indonesia. Ms S. Samaradivakara submitted M Phil thesis to the University of Kelaniya. Ms. R. Gamlath and F.F. Sharaff were awarded an M.Phil. and M.Sc. degrees from the University of Kelaniya and Ms. M. Singappuli was awarded an M.Phil degree from the University of Ruhuna.

PUBLICATIONS IN REFEREED JOURNALS 2004:

1. *Title:* Limnology of Kandy Lake Before the Outbreak of Cyanaobacteria Bloom I. Physicochemical limnology
   Authors: **Silva E.I.L.** and Samaradiwakara S.R.M.S.
   Journal: ***Sri Lanka Journal of Aquatic Science,*** **9:** 69 (2004)

2. *Title:* Limnology of Kandy Lake Before the Outbreak of Cyanaobacteria Bloom II. Photosynthetic characteristics and primary production
   Authors: **Silva E.I.L.** and Samaradiwakara S.R.M.S.
   Journal: ***Sri Lanka Journal of Aquatic Science,*** **9:** 91 (2004)

3. *Title:* Quality of irrigation water in Sri Lanka- status and trends
Authors: **Silva E.I.L.**
Journal: ***Asian Journal of Water, Environment and Pollution***, 1:5 (2004)

4. *Title:* Surface and Rainwater Chemistry in Sri Lanka – a risk of acidification
Authors: **Silva E.I.L.** and Manuweera L.
Journal: ***Asian Journal of Water, Environment and Pollution***, **1:** 79 (2004)

5. *Title:* Concentration of Trace metals in the flesh of nine species of fish found in hydropower reservoirs in Sri Lanka
Authors: **Silva E.I.L.** and Shimizu A.
Journal: ***Asian Fisheries Science,*** 17(3-4): 256 (2004)

6. *Title:* Ecology of Phytoplankton in Tropical Waters: Introduction to the topic and ecosystem changes from Sri Lanka
Authors: **Silva E.I.L.**
Journal: ***Asian Journal of Water, Environment and Pollution,*** 2004 (in press)

7.* *Title:* Seasonal abundance of two species of rotifers (*Brachionus calyciflorus* and *Keratella tropica*) in a tropical urban water body, Kandy Lake in Sri Lanka
Authors: **Silva E.I.L.,** Ekanayake M., and **Karunathilake K.M.B.C.**
Journal: ***Sri Lanka Journal of Aquatic Sciences***, **8**: 51 (2003).

8.* *Title:* Phytoplankton community structure (species composition, diversity, chlorophyll, seasonal variations and key stone variables) in four reservoirs and a volcanic lake in Monsoon Asia
Authors: Rott E., **Silva E.I.L.,** Enriquez E., and Igthamjitr S.
Journal: ***Hydrobiologia,*** 2004 (in press). [1,2]

9.* *Title:* Structure of micro-crustacean zooplankton communities in five south-east Asian water bodies
Authors: Vijverberg J., Amarasinghe P.B., Chittapalapong T., Pagulayan R.C., Ariyaratne M.G., Pamanian E.R., **Silva E.I.L.,** and Nagelkerke L.A.J.
Journal: ***Hydrobiologia,*** 2004 (in press) [1,2]

* ***Reported as 'in press' in Annual Report 2003***
[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. **Silva E.I.L.**
   Not a single drop of rain water be allowed to reach the sea without benefiting the mankind – myth or reality?
   Proceedings of International Conference on Sustainable Water Resource Management in the Changing Environment of the Monsoon Asia (November 2004). Colombo, Sri Lanka.

2. **Sharaff F.F., Silva E.I.L.,** Samanadiwakara S.R.M.S., **Karunathilake K.M.B.C.,** Kangara K.M.W.S.B., and **Weerasinghe W.M.D.**
   Trophic evolution in Kandy Lake- An outcome of urban development, land use and demographic change
   Proceedings of Internat. Conf. Sustainable Water Resources Management in the Changing Environment of the Monsoon Region, Nov. 2004 Colombo, Sri Lanka.

3. **Silva E.I.L.,** Jepperson T., and Ittekkot V.
   Biogeochmistry of mangrove-estuarine ecosystems in Sri Lanka-nutrient fluxes via seven rivers. In: Ramanadan A.P. and Alongi D.,eds.
   Proceedings of Internat. Conf. Biogeochemistry of Estuaries-Mangroves and the coastal zone management, Jawaharlal Nehru University, New Delhi, India, March, 2004

4. **Silva E.I.L.**
   Alteration of trophic status in a non-harvesting urban water body, Kandy Lake in Sri Lanka 262-269 pp.
   In: Proceedings of The Second International Symposium on Southeast Asian Water Environment. Dec. 2004 Hanoi, Vietnam

5. **Sharaff F.F.,** Silva **E.I.L.** and Abeygunawardane S.I.
   Variation of heterotrophic bacterial distribution in Kandy Lake,
   Proceedings of the 10th Annual Sessions of the Sri Lanka Association for Fisheries and Aquatic Resources.

6. **Karunathilake K.M.B.C.** and **Silva E.I.L.**
   Hydro-chemical characteristics of Kala Oya from headwaters to downstream
   Proceedings of the 10th Annual Sessions of the Sri Lanka Association for Fisheries and Aquatic Resources.

7. Jayatissa L.P., **Silva E.I.L.,** McElhiney J., Jaspars M., and Lawton L.A
   Preliminary study on the uptake, localization and translocation of Microcystins in plants and plant cells
   6th international conference on toxic cyanobacteria. Bergen, Norway 21-27, June 2004. Compilation of Abstracts, 20 p.

8. **Silva E.I.L.**
   Biogeochmistry of mangrove-estuarine ecosystems in Sri Lanka – nutrient fluxes via seven rivers
   International conference on Biogeochemistry of Estuaries- Mangroves and the coastal zone management, Jawaharlal Nehru University, New Delhi, India. (March, 2004)

9. **Silva E.I.L.**
   River linking perspective - Sri Lankan experience
   Dialogue on Interlinking Indian Rivers, Jawaharlal Nehru University, New Delhi, India. (March, 2004)

BOOKS AND MONOGRAPHS 2004:

1. **Title:* Phytoplankton characteristics, Trophic Evolution and Nutrient Dynamics in an Urban Eutrophic Lake: Kandy Lake in Sri Lanka
   Authors: **Silva E.I.L**

   In the Book: Restoration and Management of Tropical Eutrophic Lakes: Their Restoration and Management., Chapter 8, 217-260
   Editor: Reddy M.V.
   Publishers: M/s Science Publishers, Inc., USA

**** Reported as 'in press' in Annual Report 2003***

POST-GRADUATE DEGREES COMPLETED IN 2004:

1. *Name:* Gamlath G.A.R.K.
   Thesis Title: Some aspects of limnological characteristics and benthic communities of Hulu Ganga : A tributary draining the Knuckles Range
   Degree: M.Phil.
   Degree awarded by the University of Kelaniya, Sri Lanka.

2. *Name:* Sharaff F.F.
   Thesis Title: Investigations on the state of pollution and the bacterial consortia of surface water in Kandy Lake
   Degree: M.Sc.
   Degree awarded by the University of Kelaniya, Sri Lanka.

3. *Name:* Singappuli M.
   Thesis Title: Hydrography and primary productivity of Rekawa lagoon – an affected lagoon in the South Coast of Sri Lanka
   Degree: M.Phil.
   Degree awarded by the University of Ruhuna, Sri Lanka.

PROJECT: **CHEMICAL MODELING OF AQUATIC SYSTEMS**

COMMENCEMENT: 1992

INVESTIGATORS (2004):

Weerasooriya R., *Research Professor* **(Project Leader)**
Nanayakkara A. *Associate Research Professor*
Aluthpatabendi D.,*Technician*
Makehelwala M., *Volunteer Research Student*
Vitanage M.S., *M.Sc. Student*
Wickramasinghe M., *M.Sc. Student*

Collaborating laboratories:

X-ray spectroscopy and Molecular modeling
Tobschall H.J. and Hoch M. (School of Applied Geology) University of Erlangen, ***Germany (1995 to to-date)***

Vibration spectroscopy
Bandara, Atula (Dept of Chemistry) University of Peradeniya, ***Sri Lanka (1999 – to date)***

Anode stripping voltametry
Pathiratne, K.A.S. (Dept of Chemistry) University of Kelaniya, ***Sri Lanka (1998- to date)***

PROGRESS ACHIEVED *(Since inception)*:

Overall aim: Mechanistic, spectroscopic and molecular definition of solid-solution interfacial interactions.

1. Quantification of As(V) and As(III) retention mechanism of gibbsite with the aid of mechanistic modeling and vibration spectroscopy.
2. Quantification of the activation state of monochlorophenol (MCP)/ pyrite surface complexes.
3. Calculation of essential therodynamic parameters of MCP/pyrite surface complexes.
4. Reaction path modeling of 4-chlorophenol/pyrite interactions.
5. Detection of reactivity sites of kaolinite for of tributyl tin (TBT) from molecular modeling methods.
6. Calibration of TBT – kaolinite interactions using mechanistic and molecular modeling methods.

7. Retention of lead, cadmium and arsenic on gibbsite was quantified mechanistically.
8. Experimental evidence for site heterogeneity was obtained for gibbsite using a chemical method.
9. In order to account for the finite size of ions, the newly developed charge distribution multi-site surface complexation model (CD-MUSIC) was used to quantify chromium binding on goethite.
10. Chemical characterization of the kaolinite-water interfacial processes was completed. The proton, halide ion binding on kaolinite based on surface complexation was completed.
11. Chemical kinetic modeling for the complexation of copper-organic polymer systems was developed. Kinetic modeling of Fe-F system under acidic conditions was completed.
12. A direct method for the quantification of copper –fulvate complexation was developed.
13. SEM of Cd(II) adsorbtion on model minerals at different experimental conditions was completed.
14. Determination of near-surface solid composition of the goethite-copper system to elucidate Cu-inter-particle diffusion from surface precipitation on external surfaces was completed. X-ray photon spectroscopy was used to achieve these results.
15. Essential unit processes of drinking water treatment for fluoride, nitrate, and selected organic-Cl were completed. These processes have also been modeled with ENVIRONPRO software (Project objectives were revised to meet with the current IFS reorientation towards themes of basic science).
16. A precise mechanistic model was developed to understand the formation of N-nitrosation (project objectives were revised to meet the current IFS reorientation towards basic science)

Number of publications in refereed journals: 37

PROJECT OUTPUT 2004:

TBT- montmorillonite: Interactions of the pollutant tributyltin (TBT) with mineral surfaces affects its distribution and transport in aqueous systems. In the present work, model calculations are reported that quantify TBT adsorption onto pure-phase montmorillonite (sample SWy) under various pH and salinity conditions that are important from an environmental perspective. The pH level in the system is of substantial interest because it affects the speciation of TBT in solution as well as the surface properties of the solid phase, which are both important for adsorption reactions. The model is based on the generalized diffused layer model that includes >X - sites in order to account for the cation exchange effects of TBT attraction. The presence of >AlOH and >SiOH sites at the mineral surface was not considered separately during calculation. Instead, non-selective sites (>SOH) versus selective sites (>SsOH) were distinguished with respect to the sorptive sites on montmorillonite. The latter are charecterized by a high affinity of TBT bonding. Both sorptive sites exhibit the same protolysis constants but different TBT binding constants [$\log K_{TBT/2}$ = -1.18 for (>SOH), $\log K_{TBT/1}$ = 3.98 for (>SsOH)].

$Log K_{X/TBT}$ for the cation exchange reaction was determined as between 3.05 – 4.14. The results indicate that the inclusion of selective sites during calculations is essential for quantifying pH-dependent TBT adsorption successfully. The parameters determined for the TBT adsorption onto pure-phase montmorillonite were subsequently used to calculate pH-dependent TBT adsorption onto natural montmorillonite-rich sediment.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Modeling interactions of kaolinite-tributyl tin interface
   Authors: Hoch M. and **Weerasooriya R.**
   Journal: ***Chemosphere***, 2004 (in press)[1,2]

2. *Title:* New model calculations of pH depending tributyltin (TBT) adsorption onto monmorillonite and monmorillonite -rich sediment
   Authors: Hoch M. and **Weerasooriya R.**
   Journal: ***Environmental Science and Technology***, 2004 (in press)[1,2]

3.* *Title:* Macroscopic and Vibration Spectroscopic Evidence for Specific Bonding of Arsenate on Gibbsite
   Authors: **Weerasooriya R.**, Tobshcall H.J., Wijesekara D., and Bandara A.
   Journal: ***Chemosphere***, **55:** 1259 (2004)[1,2]

* ***Reported as 'in press' in Annual Report 2003***
[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. **Weerasooriya R.** and Tobschall H.J.
   1-pK modelling of proton binding onto pyrite
   Workshop of Forschungszentrum, Karlsruhe, March 24th – 25th 2004 Germany.

2. Mieander M.M., **Weerasooriya R.**, and Tobschall, H.J.
   Thermodynamics of monochlorophenol-pyrite complexes at activation state
   Goldsmit Conference of Earth Sciences 2004, Denmark.

3. **Vitanage M.S.**, Chandrajith R., Bandara A., and **Weerasooriya R**
   Mechanistic modeling of arsenic retention on natural red earth in simulated environmental systems
   International Conference on Arsenic 2004, Chile.

PROJECT: **STRUCTURAL GEOLOGY**

COMMENCEMENT: 1995

INVESTIGATORS(2004):

Kehelpannala K.V.W., *Senior Research Fellow* **(Project Leader)**
Kröner A., *Honorary Research Professor*
Yoshida M., *Honorary Visiting Research Professor*
Kleinschrodt R., *Visiting Associate Research Professor*
Ranaweera L.V., *Research Assistant*

PROGRESS ACHIEVED *(Since inception)*:

The Structural Geology project was started in 1995 with a view to study (i) the origin of structures and mineral deposits in the lower crust, (ii) the behaviour of lower crustal rocks during ductile deformation, (iii) the mechanisms of plate movements during Proterozoic, (iv) possible mechanisms of assembly and break-up of supercontinents, (v) deformation- and fluid-controlled lower crustal processes, such as migmatization, charnockitization, retrogression and metasomatism, (vi) vein graphite mineralization, and (vii) brittle deformation, neotectonics and seismic activities in an exhumed section of the lower crust exposed in Sri Lanka.

During the last eight years, the Structural Geology project contributed to the structural evolution of the lower crust exposed in Sri Lanka and to understanding the significance of mantle-derived fluids on the precipitation of post-metamorphic vein graphite. The data so far gathered led us to established that the middle to lower crust exposed in Sri Lanka has been formed by the amalgamation of three different plates collided at two separate stages during the final assembly of the Gondwana supercontinent at about 610-550 Ma. The most intensely developed and easily visible ductile structures in the basement rocks of Sri Lanka have been formed by the above two collisions. We have been able to recognize some structures formed even before the above collisions, probably related to the accretion and break-up of the supercontinent Rodinia that existed before 750 Ma ago. Some results obtained in relation to deformation-controlled migmatization and sheared-controlled charnockitization, retrogression and metasomatism are important in understanding these lower crustal processes. In addition, the project made a valuable contribution to understand neotectonics and seismic activities in Sri Lanka that makes part of the exhumed lower crust. With limited resources, important results obtained during the last 10 years were published in refereed journals (18 papers), in the Second Edition of the National Atlas of Sri Lanka (three chapters), in proceeding volumes (14 papers) and in the form of abstracts (24).

In recognition of our work, the Project Leader has been honoured by awarding a DAAD Invitation Research Fellowship from the German Academic Exchange Service to Germany and a JSPS Invitation Research Fellowship from the Japan Society for Promotion of Science to Japan and was invited by international organizations to participate in about eleven international symposia and workshops held in India, China,

Singapore, Japan and Sri Lanka to present some of the results of the project. Since the inception of the project, the Project Leader has delivered over 30 invited/public/special lectures in Sri Lanka, India, Singapore, Hong Kong, China and Japan. Further, the Project Leader has been appointed as a Fellow of the Geological Society of India and as a member of the Steering Committee of the International Association for Gondwana Research, Japan and has been the Sri Lankan convenor/researcher of the following international projects:

1. UNESCO-International Geological Correlation Programme (IGCP 368) project on "Proterozoic Events in East Gondwana".

2. UNESCO- International Geological Correlation Programme (IGCP 440) project on "Rodinia Assembly and Breakup".

3. International project on "Structure, Composition and Evolution of the South Indian and Sri Lankan Granulite Terrains from Deep Seismic Profiling and other Geophysical and Geological Investigations: A LEGENDS Initiative".

In addition, the Project Leader is the guest editor of the Journal of Asian Earth Sciences (Elsevier), Special Issue on "The role of Sri Lanka and associated continental blocks in the assembly and break-up of Rodinia and Gondwana" (In final preparation).

PROJECT OUTPUT 2004:

During the year 2004, in addition to the following studies, some of the work started in the previous year was continued.

1. Geological and structural studies along the boundary shear zones of the major crustal blocks in Sri Lanka were continued. During the study, evidences were found along the boundary between the western crustal block (the Wanni Complex) of Sri Lanka and the central crustal block (the Highland Complex) indicating that the boundary is a deep part of a palaeo-subduction zone. This work is being continued.

2. X-ray photoelectron spectroscopic (XPS) study of different types of natural graphite (vein graphite and disseminated graphite in marble and metapelitic rocks) from Sri Lanka was carried out at the Shizuoka University, Japan by the Project Leader with a view to distinguish between metamorphic graphite and fluid-deposited graphite. In addition, this study provided XPS spectral data from natural graphite. This work is being continued.

3. Catalogues (from the US Geological Survey and Meteorology Department of India) of some ancient earthquakes that were reported to have occurred in Sri Lanka and close to the island were studied. This study suggests that Sri Lanka is situated in a belt of moderate earthquakes extending in a NE-SW direction. A detailed field study will be undertaken to investigate archaeological evidences for any such earthquakes reported to have taken place in the country.

PUBLICATIONS IN REFEREED JOURNALS IN 2004:

1. *Title:* Arc accretion around Sri Lanka during the assembly of Gondwana
   Author: **Kehelpannala K.V.W.**
   Journal: ***Gondwana Research***, **7**: 1323-1328 (2004)[2]

2. *Title:* Isotopic zonations in graphite and calcite and their implications for crustal evolution of Gondwana continents
   Authors: Hideki W., **Kehelpannala K.V.W.**, and Satish-Kumar M.
   Journal: ***Gondwana Research***, **7**: 1397-1399 (2004)[2]

3.* *Title:* Geochemical evidence for a Neoproterozoic magmatic continental margin in Sri Lanka - Relevance for the Rodinia-Gondwana supercontinent cycle
   Authors: Willbold M., Hegner E., **Kleinschrodt R.**, Stosch H.-G., **Kehelpannala K.V.W.**, and Dulski, P.
   Journal: ***Precambrian Research***, **130**: 185-198 (2004)[1,2]

4.* *Title:* Structural Evolution of the middle to lower crust in Sri Lanka
   Author: **Kehelpannala K.V.W.**
   Journal: ***Journal of the Geological Society of Sri Lanka,*****11**: 45 (2004)

5.‡ *Title:* Metasomatic calcsilicate rocks: an example of infiltration metasomatism from the Highland Complex of Sri Lanka
   Author: **Kleinschrodt R.**
   Journal: ***Journal of the Geological Society of Sri Lanka,*** **11**: 21 (2003)

6. *Title:* Metamorphic evolution of high pressure and ultrahigh-temperature granulites from the Highland Complex, Sri Lanka
   Authors: Osanai Y., Sajeev K., Owada M., and **Kehelpannala K.V.W.**, Prame W.K.B.N., and Nakano N.
   Journal: ***Journal of Asian Earth Sciences,*** *Special Issue,*(in press)[2]

7.* *Title:* Diversity in the position of Sri Lanka within the Gondwana land ensemble
   Authors: **Yoshida M.**, Tani Y., Rajesh H.M., and Santosh M.
   Journal: ***Journal of the Geological Society of Sri Lanka,*** **11**: 5 (2003)

* ***Reported as 'in press' in Annual Report 2003***
‡ ***This article did not appear in Annual Research Report 2003***
[1] ***Listed in the Science Citation Index in 2004***
[2] ***Listed in the Science Citation Index-expanded in 2004***

BOOKS AND MONOGRAPHS IN 2004:

1. *Title:* Seismicity
   Author: **Kehelpannala K.V.W.**
   In the Book: Section 3.4 -*National Atlas of Sri Lanka,* Second Edition
   Editors: Survey Department of Sri Lanka (in press).

In this article, the author has pridicted tsunami hitings both in the western and eastern costal belts of Sri Lanka. On 26.12.2004 Sri Lanka was hit by a tsunami.

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2004:

1. **Kehelpannala K.V.W.**
   Palaeoproterozoic to recent tectonisms in Sri Lanka. (Extended Abstract). *International Symposium and Field Workshop on "Tectonic Evolution of the Precambrian Southern Granulite Terrain, Southern India and Gondwanian Correlation", 18-25 February 2004, Abstracts and Excursion Guide, National Geophysical Research, Hyderabad, India, 95-96.*

2. **Kröner A.** and **Kehelpannala K.V.W.**
   Which role did Sri Lanka and southern India play in the formation of Gondwana?
   International Symposium and Field Workshop on "Tectonic Evolution of the Precambrian Southern Granulite Terrain, Southern India and Gondwanian Correlation", 18-25 February 2004, Abstracts and Excursion Guide, National Geophysical Research, Hyderabad, India, 12.

3. **Kehelpannala K.V.W.**
   Pan-African Crustal Accretion in Sri Lanka. International Joint Asia Oceania Geoscience Society
   1st Annual Meeting and Asia Pacific Association for Hydrology and Water Resources 2nd Conference", 5-9 July 2004, Singapore, 56-57.

INVITED LECTURES/CONFERENCES ATTENDED IN 2004:

1. **Kehelpannala K.V.W.**
   Lecture on "Palaeoproterozoic to recent tectonisms in Sri Lanka" *International Symposium and Field Workshop on "Tectonic Evolution of the Precambrian Southern Granulite Terrain, Southern India and Gondwanian Correlation", held at the National Institute of Geophysical Research, Hyderabad, India on 25 February 2004.*

2. **Kehelpannala K.V.W.**
   Delivered the Prof. M.N. Vishwanathaiah Endowment Lecture *Department of Geology, University of Mysore, India, 03rd March 2004.*

3. **Kehelpannala K.V.W.**
Invited lecture on "Geology of Sri Lanka"
Department of Geology, Anna University, Chennai, India, 04th March 2004.

4. **Kehelpannala K.V.W.**
Invited lecture on "Shear zones tectonics of Sri Lanka and the relationship between Sri Lanka and India"
Geological Survey of India, Chennai, India, 04th March 2004.

5. **Kehelpannala K.V.W.**
Invited lecture on "Landslides in Sri Lanka" delivered at the Deraniyagala Divisional Secretariat.
This was jointly organized by the Section D of the Sri Lanka Association for the Advancement of Science and the Geological Society of Sri Lanka, 28th May 2004.

6. **Kehelpannala K.V.W.**
Invited lecture on "Pan-African Crustal Accretion in Sri Lanka"
International Joint Asia Oceania Geoscience Society 1st Annual Meeting and Asia Pacific Association for Hydrology and Water Resources 2nd Conference", 5-9 July 2004, Singapore.

7. **Kehelpannala K.V.W.**
Special lecture on "Arc accretion around Sri Lanka during the assembly of Gondwana"
International Symposium and Field Workshop on "Gondwana Evolution and Dispersal", Kochi, Japan, 13-15 November 2004.

8. **Kehelpannala K.V.W.**
Invited lecture on "The role of Sri Lanka in the reconstruction of Gondwana" *Department of Earth Sciences, University of Hong Kong, Hong Kong on 23 November 2004.*

OTHER CONTRIBUTIONS:

1. Organized a field excursion in Sri Lanka for geology graduate students from the University of Cologne, Germany, 10-16 February 2004.

2. Organized a one-day workshop on "Landslides" held at the Deraniyagala Divisional Secretariat 28th May 2004. This was organized in collaboration with Section D, Sri Lanka Association for the Advancement of Science.

3. The Project Leader was a Member of the Scientific Programme Committee, International Symposium and Field Workshop on "Gondwana Evolution and Dispersal", Kochi, Japan, 13-15 November 2004.

4. Conducted a field excursion to Kahatagaha Graphite Mines jointly organized by the Sri Lanka Association for the Advancement of Science and the Geological Society of Sri Lanka on 23 October 2004.

SCIENCE DISSEMINATION

Tilakaratne C.T.K. and Sellam S.

Research colloquia, public lectures, research meetings and the science popularization programme for schools were conducted as in the previous years in keeping with the IFS commitment to fundamental science.

(A) Research meetings, research colloquia, special lectures, and public lectures

Research meetings: Research meetings were conducted by the research assistants of the IFS. These meetings provide a platform to present their research findings and discuss their research problems with the peers.

Research colloquia: Scientists with expertise in their fields of research were invited to talk to their colleagues at research colloquia.

Special lectures: These are arranged to expose researchers in the IFS and other institutions, to visitors who come to IFS.

Public lectures: These promote the public understanding of science.

(B) Awareness and educational programmes for students

School Science Programme: (SSP)
IFS conducts an annual school science programme to bring together a selected batch of G.C.E. O/L qualified students from different parts of the country. This programme aims to expose young minds to frontier topics in science to motivate them and arouse curiosity. In 2004 SSP was held for four days and this was the fourteenth programme of this kind. 136 students participated in this programme.

Special lectures on:

Growing our own engery...and fertility!
by Dr. Ray Wijewardena
Air pollution in Kandy and its health effect
by Prof. O.A. Illeperuma
Uses and concerns of pesticides
by Dr. G.K. Manuweera

were organized for students of the Kandy zone. This was organized jointly with Sri Lanka Association for the Advancement of Science (SLAAS).

Visits: Lab visits were organised for

Postgraduate students
Undergraduate students
Students from other institutions
School children and teachers

Special lecture on IFS and its activities were prepared in advance to enable these students to understand the IFS activities better.

(C) Preparation of Scientific reports/bulletins:

Annual Research Report 2003 was compiled. Mid year report and four quarterly research reports were prepared. Scientific part of the Administrative Report 2003 was prepared in English, Sinhala and Tamil. Scientific part of the Corporate Plan 2003 was compiled.

On request, Statistical and Scietific Reports about IFS were prepared for other institutions (National Science Foundation, National Library and University of Colombo).

Personal Citations of each IFS researcher from 1995 to 2002 were calculated.

Pragñā- IFS Science Bulletin: Two volumes of the Bulletin were published this year. These were distributed to schools (With A/L classes), research institutes, universities and scientists.

(D) Science and Technology Promotion

English-Sinhala Science glossary (electronic) with an intelligent search engine was published in compact disc form jointly with Dr. A. Nanayakkara. This contains about 41,800 words in the fields of Biology, Chemistry, Physics and Mathematics.

Development of English-Tamil glossary is in progress. Data files for Biology and Mathematics were completed and remaining data files are in preparation.

(E) Auditorium was rented out for outsiders on nine occasions.

RESEARCH MEETINGS, RESEARCH COLLOQUIA AND SPECIAL LECTURES

RESEARCH MEETINGS

10.03.2004 **Status and distribution of Heterotropic Bacteria in Kandy Lake**
Ms. F.F. Sharaff Mushtaq, Research Assistant, IFS

17.03.2004 **Hydrochemical characteristics of Kala Oya from Headwaters to downstream**
Ms. B.C. Karunathilake, Research Assistant, IFS

24.03.2004 **Level spacing distributions of multi dimensional potentials vs one dimensional potentials**
Ms. P. Wickramarachchi, Research Assistant, IFS

21.04.2004 **Legume Nodulating Rhizobia Fix Nitrogen In Microbial Biofilms**
Ms. H.S. Jayasinghearachchi, Research Assistant, IFS

07.07.2004 **Rice - *azorhizobium caulinodans* - n_2 fixing association: effects of phenolics and carbon sources**
Ms. A.P. Morawaka Arachchi, Research Assistant, IFS

29.07.2004 **Sacrificial Photoreduction of water with Cu_2O coated TiO_2**
Mr. P.K.D.D.P. Pitigala, Research Assistant, IFS

07.10.2004 **Pharmacological properties of vegetable greens consumed in Sri Lanka**
Ms. B.M.G.K. Balasuriya, Research Assistant, IFS

29.11.2004 **Chemistry and Bioactivity studies of Sri Lankan Flora**
Ms. M.T. Napagoda, Research Assistant, IFS

30.11.2004 **Chemistry and Bioactivity studies of *garcinia mangostana***
Ms. K.G.N.P. Piyasena, Research Assistant, IFS

01.12.2004 **Sensitization of nanostructured TiO_2 by electrostatic coupling of ionic dyes to ionic absorbates**
Ms. M.K.I. Seneviratne, Research Meeting, IFS

08.12.2004 **Chemical constituents of the fruits of *Artocarpus altilis***
Ms. N.R. Amarasinghe, Research Assistant, IFS

23.12.2004 **Soil litter controls on nutrient availabilities in natural and managed ecosystems**
Ms. R.Ratnayake, Research Assistant, IFS

Research Colloquia

15.06.2004 **Search for bioactive molecules from Sri Lankan flora**
Prof. H.R.W. Dharmaratne, Associate Research Professor, IFS

Special Lecture

19.05.2004 **Frontier Research Activities in Hydraulic and Environmental Engineering (Saitama, Japan)**
Prof. Norino Tanaka, Saitama University, Japan

21.07.2004 **Diabetics**
Dr. Thilak Abeysekera, Dialysis Unit, General Hospital, Kandy

09.08.2004 **String Theory – A unified theory of fundamental interactions**
Prof. Senarath de Alwis, University of Colorado, USA

12.11.2004 **50th Anniversary of the solar cells**
Prof. Han J. Queisser, Distinguished Visiting Professor, Institute of Fundamental Studies and former Director, Max Planck Institute Stuftgart

Public Lecture

31.12.2004 **Earthquakes, Tsunamis and Damages: Where we went wrong?**
Dr. K.V.W. Kehelpannala, Senior Research Fellow, IFS

Seminars and Workshops

10.02.2004 Introductory Seminar - Excursion on Tropical Ecology in Sri Lanka. Organized and coordinated by Institute of Fundamental Studies in collaboration with Institute of Botany, University of Innsbruck, Austria at IFS.

12.05.2004.1 **Annual Research Review** at IFS.

02.11.2004 Open forum on Atomic Spectroscopy conducted by Prof. R. Weerasooriya, Research Professor, IFS at IFS.

06.11.2004 to 07.11.2004
Short-course on Semiconductor Physics and Photovoltaics conducted by **Prof. Han J Queisser** Distinguished Visiting Professor, Institute of Fundamental Studies and former Director, Max Planck Institute, Stuftgart at IFS.

23.11.2004 Short course on Semiconductor Physics and Technology conducted by **Prof. Hans J Queisser** Distinguished Visiting Professor, Institute of Fundamental Studies and former Director, Max Planck Institute, Stuftgart at IFS.

22.12.2004 **One day Short Course** conducted by Prof. Ng Wun Jern, Environmental Science and Engineering Program, Faculty of Engineering, National University of Singapore on **Biological Treatment for Industrial Wastewater** at IFS - organized by IFS and Environmental Engineering Laboratory, Faculty of Engineering, University of Peradeniya .

EDUCATIONAL VISIT

25.02.2004 Students from College of Chemistry, Institute of Chemistry Ceylon, Colombo.

28.05.2004 Undergraduate students from Uva Campus.

22.07.2004 Students from Divulapitiya Gnanodaya Central College.

23.07.2004 Students from Bandarawela Madhya Maha Vidyalaya, Bandarawela.

05.08.2004 Teachers from Amarasuriya Teachers Vidyalaya, Galle.

13.08.2004 Students from Ananda Madhya Maha Vidyalaya, Elpitiya.

22.10.2004 Undergraduate students from Sabaragamuwa University.

27.10.2004 Students from Institute of Business Computing, Colombo.

26.12.2004 Lab visit by the participants of Ruhuna International School on Computational and Mathematical Physics (RISCMAP) 2004

SPECIAL PROGRAMME FOR SCHOOL CHILDREN

23.06.2004 Lecture on **Growing our own energy...and fertility!** conducted by Dr. Ray Wijewardene, organised by The Sri Lanka Association for the Advancement of Science (SLAAS) and The Institute of Fundamental Studies (IFS), at the IFS.

14.07.2004 Lecture on:

1) **Air pollution in Kandy and its health effects** by Prof. O.A.Ileperuma, Professor of Chemistry, University of Peradeniya

2) **Uses and concerns of pesticides** by Dr. G.K. Manuweera, Registrar of Pesticides, Department of Agriculture, Peradeniya

organised by The Sri Lanka Association for the Advancement of Science (SLAAS) and The Institute of Fundamental Studies (IFS) at IFS.

SCHOOL SCIENCE PROGRAMME 2004
25th August – 28th August 2004

Lectures

Wednesday 25th August

Why night is dark?
Prof. K. Tennakone

Thursday 26th August

Fifty years since DNA
Dr. M.C.M. Iqbal

Wonders in Chemistry
Dr. J. Bandara

Friday 27th August

Let not a single drop of rain water be allowed to reach the sea ..... –myth or reality?
Prof. E.I.L. Silva

Uses and concerns of Pesticides
Dr. G.K. Manuweera

Einstein in the 21st century
Dr. A. Nanayakkara

Saturday 28th August

From Galileo and Newton to Jupiter, Saturn, and beyond
Prof. W. Stuiver

RESEARCH STAFF 2004

The period mentioned within brackets shows their stay at IFS

Senior Research Professor

Director/IFS - Tennakone K.	*(1988-todate)*

Research Professor

Weerasooriya S.V.R.	*(1986-todate)*

Associate Research Professor

Dharmaratne H.R.W.	*(1992-todate)*
Jayasinghe J.H.M.U.L.B.	*(1992-todate)*
Nanayakkara A.	*(2000-todate)*
Silva E.I.L.	*(1988-todate)*

Senior Research Fellow

Bandara J.	*(1999-todate)*
Iqbal M.C.M.	*(1997-todate)*
Kehelpannala K.V.W.	*(1994-todate)*
Ramanayake S.M.S.D.	*(1988-todate)*
Senadeera G.K.R.	*(1999-todate)*
Senevirathne P.R.G.	*(1993-todate)*

Research Fellow

Jeyanandarajah P.	*(2001-2004)*
Maganaarachchi D.M.	*(December 2004-todate)*

Visiting Research Staff

Honorary Research Professor

Kovoor A.	*(2001-todate)*
Kröner A.	*(2001-todate)*

Distinguished Visiting Research Professor

Queisser H.J.	*(2003-todate)*

Honorary Visiting Research Professor

Yoshida M.	*(2000-todate)*

Honorary Visiting Professor

Schiemmer F.	*(August 2004-todate)*

Visiting Research Professor

Dias H.V.R.	*(1999-todate)*
Fernando G.W.	*(1997-todate)*
Gunaratne G.H.	*(1997-todate)*
Perera U.	*(2000-todate)*
Wijewardena L.C.R.	*(1997-todate)*

Visiting Associate Research Professor

Keinschrodt R.	*(2000-todate)*

Honorary Senior Research Fellow

Dittus W.P.J.	*(1983-todate)*

Visiting Senior Research Fellow

Wijayantha K.G.U.	*(November 2004-todate)*

Visiting Scientist

Perera V.P.S.	*(March 2004-todate)*
Sivakumar V.	*(October 2004-todate)*
Wanigasekera W.M.A.P.	*(2002-2004)*

RESEARCH ASSISTANTS 2004

The period mentioned within brackets shows their stay at IFS

Research Assistant (Grade I)

Rathnayake R.R.	*(15.01.2002-todate)*
Sepalika J.A.H.	*(02.11.1998-14.08.2004)*
Wijesekara K.B.	*(16.06.2003-todate)*

Research Assistant (Grade II)

Amarasinghe N.R.	*(17.11.2003-todate)*
Ariyasena J.A.T.C.	*(09.08.2004-12.08.2004)*
Balasooriya B.M.G.K.	*(03.11.2003-todate)*
Bandaranayake K.M.P.	*(17.04.2000-16.04.2004)*
Colonne P.M.	*(15.07.2003-15.06.2004)*
Fernando W.I.T.	*(15.07.2002-todate)*
Indrasena I.K.	*(15.12.2003-19.11.2004)*
Jayasekera H.W.	*(17.11.2003-28.02.2004)*
Jayaweera P.V.V.	*(03.04.2000-01.04.2004)*
Karunathilake K.M.B.C.	*(15.07.2002-todate)*
Kumari H.K.J.S.	*(01.12.2004-todate)*
Kumari H.R.S.N.	*(01.01.2004-08.01.2004)*
Maligaspe E.C.	*(01.11.2004-todate)*
Medawala M.M.W.S.	*(27.11.2003-07.07.2004)*
Meemaduma V.N.	*(16.08.1999-13.02.2004)*
Morawaka Arachchi A.P.	*(15.07.2002-08.09.2004)*
Napagoda M.T.	*(01.07.2002-todate)*
Nethu de Silva	*(17.11.2004-todate)*
Pathirathne W.M.T.C.	*(01.12.2003-28.10.2004)*
Pitigala P.K.D.D.P.	*(01.07.2002-todate)*
Piyasena K.G.N.	*(01.06.2002-todate)*
Premalal E.V.A.	*(20.05.2004-todate)*
Rajapakse C.S.K.	*(11.01.2004-20.07.2004)*
Ranaweera L.V.	*(03.11.2003-todate)*
Senevirathne M.K.I.	*(01.09.2003-todate)*
Seneviratne H.R.W.U.	*(20.12.2004-todate)*
Seneviratne S.B.M.S.	*(23.01.2004-todate)*
Sharaff F.F.	*(02.04.2001-30.07.2004)*
Vithanage M.S.	*(15.12.2004-todate)*
Weerasinghe W.M.D.	*(01.01.2004-todate)*
Wickramaarachchi P.	*(01.07.2003-07.08.2004)*
Wijesekera T.P.	*(01.05.2004-todate)*

Project Leaders are responsible for their contribution to compile this document.