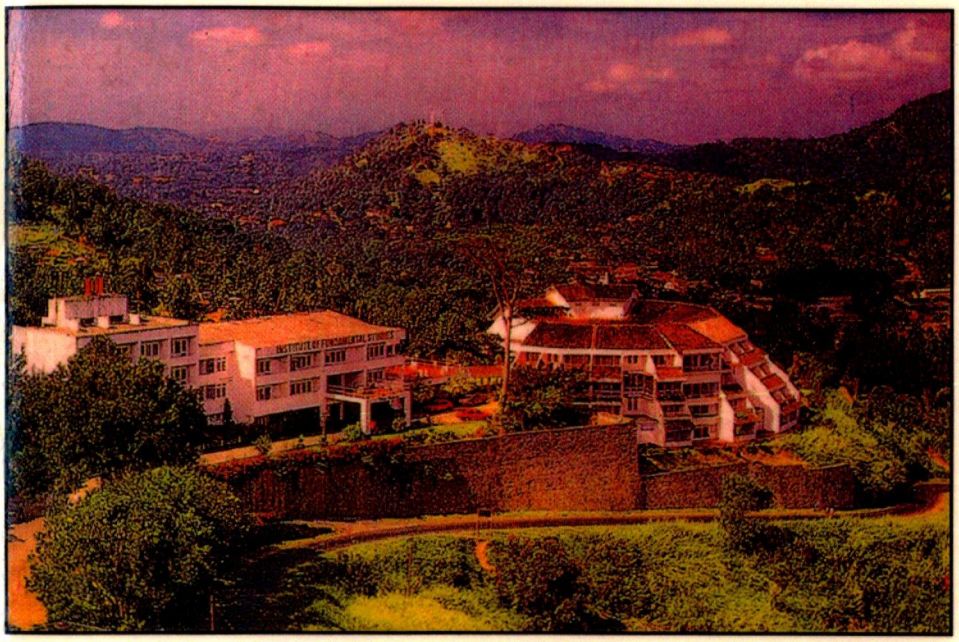
ANNUAL RESEARCH REPORT

2003



Institute of Fundamental Studies
Hantana Road
Kandy

INSTITUTE OF FUNDAMENTAL STUDIES

ANNUAL RESEARCH REPORT 2003

Compiled by
Science Dissemination unit

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cont.

PUBLICATIONS IN REFEREED JOURNALS 2003

1. **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*** (in press) [1,2].

2. **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*** (in press) [1,2].

3.* **Bandaranayake K.M.P., Jayaweera P.V.V.,** and **Tennakone K.** Dye-sensitization of magnesium oxide coated cadmium sulphide. ***Solar Energy Materials and Solar Cells,*** **76:** 57 (2003) [1,2].

4.* Binu-Lal S.S., **Kehelpannala K.V.W.,** Satish-Kumar M., and Wada H. Multistage graphite precipitation through protracted fluid flow in sheared metagranitoid, Digana, Sri Lanka: evidence from stable isotope. ***Chemical Geology,*** **197:** 253 (2003) [1,2].

5. **Dias H. V. R.** and Jin W. Syntheses of Aluminium and Zinc Alkyl Complexes of a Highly Fluorinated Tris(pyrazolyl)borate using [HB(3,5-$(CF_3)_2Pz)_3$]Ag(THF) as the Ligand Transfer Agent. ***Inorganic Chemistry*** **42:** 5034 (2003) [1,2].

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11. **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*** (in press) [1,2].

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13. **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*** (in press) [2].

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20.* **Jayasinghe U.L.B., Kumarihamy B.M.M.,** Bandara A.G.D., Waiblinger J., and Kraus W. Antifeedant activity of some Sri Lankan plants. ***Natural Product Research,*** 17: 5 (2003)[2].

21. **Kehelpannala K.V.W.** Structural Evolution of the middle to lower crust in Sri Lanka. ***Journal of the Geological Society of Sri Lanka*** (in press).

22.* **Kröner A., Kehelpannala K.V.W.,** and Hegner H. Ca. 750-1100 Ma magmatic events and Grenville-age deformation in Sri Lanka: relevance for Rodinia supercontinent formation and dispersal, and Gondwana amalgamation. ***Journal of Asian Earth Sciences,*** **22:** 279 (2003) [2].

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31. **Nanayakkara A.** Higher-order semiclassical energy expansions for potentials with non-integer powers. ***Pramana Journal of Physics*, 61:** 739 (2003) [1,2].

32.* **Nanayakkara A.** and Abayaratne C. Identification of Semiclassical Chaos in 2D *PT*-symmetric Systems. ***Canadian Journal of Physics*, 81**: 835 (2003) [1,2].

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35. **Perera V.P.S., Senadeera G.K.R.**, and **Tennakone K.** Sensitization of aluminium chloride adsorbed tin (iv) oxide nanocrystalline films with Rose Bengal. ***Journal of colloid and interface Science*, 265:** 428 (2003) [1,2].

36. **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 multiplayer semiconductor nanostructures. ***Journal of Physical Chemistry B, American Chemical Society*** (in press) [1,2].

37. **Perera V.P.S., Pitigala P.K.D.D.P., Bandaranayake K.M.P., Perera A.G.U.**, Hastings G., and **Tennakone K.** Deposition of the thin films of the conducting polymer polythiocyanogen and construction of a photovoltaic device. ***Synthetic Metals*** (in press) [1,2].

38. 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*** (in press) [1,2].

39.* **Ramanayake S.M.S.D.** and Wanniarachchi W.A.V.R. Organogenesis in callus derived from an adult giant bamboo (*Dendrocalamus giganteus* Wall. Ex Munro). ***Scientia Horticulturae*, 98:** 195 (2003) [1,2].

40. **Ramanayake S.M.S.D.** and **Weerawardene T.E.** Flowering in a bamboo, *Melocanna baccifera* (Roxburgh) Kuerz ex Scheels (Bambusoidae, Poaceae). ***Botanical Journal of the Linnean Society*, 143(3):** 287 (2003) [1,2].

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42. 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].

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44. **Senadeera G.K.R.**, Nakamura K., Kitamura T., Wada Y., and Yanagida S. Fabrication of highly efficient polythiophene sensitized metal oxide photovoltaic cells. ***Applied Physics Letters*, 83(26):** 5470 (in press) [1,2].

45. **Seneviratne G.** and **Jayasinghearachchi H.S.** Phenolic acids: Possible agents of modifying N_2-fixing symbiosis through rhizobial alteration? ***Plant and Soil*, 252:** 385 (2003) [1,2].

46. **Seneviratne G.** Global warming and terrestrial carbon sequestration. ***Journal of Biosciences*, 28:** 653 (2003) [1,2].

47. **Seneviratne G.** Development of eco-friendly, beneficial microbial biofilms. ***Current Science,*** **85:** 1395 (2003) [1,2].

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49. **Seneviratne G.** and. **Jayasinghearachchi H.S.** Mycelial colonization by bradyrhizobia and azorhizobia. ***Journal of Biosciences,*** **28:** 243 (2003) [1,2].

50. **Seneviratne G.** and Somapala K.L.A. Litter controls on soil nitrous oxide emission. ***Current Science,*** **84:** 498 (2003) [1,2].

51. **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*** (in press).

52. **Silva E.I.L.** Emergence of a *Microcystis* bloom in an urban water body, Kandy Lake in Sri Lanka. ***Current Science,*** **5(6):** 723 (2003) [1,2].

53. **Tennakone K.** and **Jayaweera P.V.V.** Depleted Quantum Nanowire in an electrolytic medium. ***Superlattices and Microstructure,*** **33:** 23 (2003) [1,2].

54.* **Tennakone K., Jayaweera P.V.V.,** and **Bandaranayake K.M.P.** Dye-sensitized photoelectrochemical and solid-state solar cells. ***Journal of Photochemistry and Photobiology A: Chemistry,*** **158:** 125 (2003) [1,2].

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

56.* **Weerasooriya R.**, Tobshcall H.J., **Wijesekara D.**, Arachchige E.K.I.A.U.K., and Pathiratne K.A.S. On the mechanistic modelling of As (III) adsorption on gibbsite. ***Chemosphere,*** **51(9):** 1001 (2003) [1,2].

57.* 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].

58. 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*** (in press) [1,2].

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Names of the IFS staff members are in bold letters
†This article did not appear in Annual Research Report 2002
****Reported as "in press" in the Annual Research Report 2002***
[1] Listed in the science citation index in 2003
[2] Listed in the science citation index- expanded in 2003

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 2002)

JOURNAL	IMPACT FACTOR
American Journal of Primatology	1.214
American Journal of Physics	0.718
Applied Catalysis B: Environmental	2.866
Applied Physics Letters	4.207
Botanical Journal of the Linnean Society	1.114
Brazilian Journal of Physics	0.678
Bulletin of the Chemical Society of Japan	1.213
Canadian Journal of Physics	0.760
Chemical Geology	2.437
Chemosphere	1.461
Current Science	0.533
Czechoslovak Journal of Physics	0.311
Electrochemistry Communications	1.906
Episodes	0.941
Hydrobiologia	0.694
Inorganic Chemistry	2.950
Journal of Asian Earth Sciences	1.071
Journal of Biomechanics	1.889
Journal of Biosciences	0.606
Journal of Colloid and Interface Science	1.466
Journal of High Energy Physics	6.854
Journal of Photochemistry and Photobiology A	1.297
Journal of Physical Chemistry B, American Chemical Society	3.611
Journal of Plant Physiology	0.941
Journal of the Geological Society of Sri Lanka	x
Langmuir	3.248
Medical and Veterinary Entomology	1.148
Natural Product Research	0.527
Physical Review D	4.358
Phytochemical Analysis	1.439
Phytochemistry	1.686
Phytomedicine	1.377
Phytoparasitica	0.646
Phytotherapy Research	0.875
Plant and Soil	1.290
Polyhedron	1.414
Pramana-Journal of Physics	0.324
Precambrian Research	2.413
Scientia Horticulturae	0.529
Semiconductor Science and Technology	1.241
Solar Energy Materials and Solar Cells	1.258

JOURNAL	IMPACT FACTOR
Sri Lanka Journal of Aquatic Science	x
Steroids	2.524
Superlattices and Microstructure	0.876
Synthetic Metals	1.187
Tetrahedron Letters	2.357

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

COMMENCEMENT: 1999

INVESTIGATORS (2003):

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 (an example of which is shown in Figure 1) 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 form 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 (Figure 1), 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 T 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.

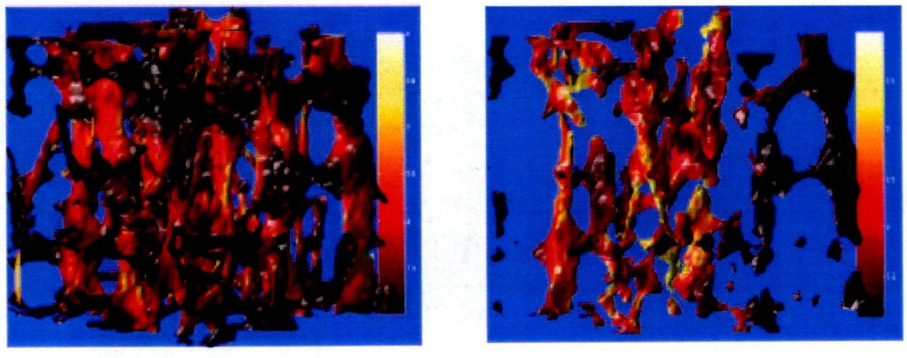


Figure 1: (a) Stresses on a uniformly compressed healthy bone are (fairly) evenly distributed on the network, while (b) those on a weak network are concentrated on a few pathways. These calculations, conducted on computer models derived from-digitized images of human bone samples, confirm results deduced from the struts-and-nodes model

We are currently conducting numerical and experimental studies on cadaver bone samples form 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. This is demonstrated in Figure 1 which shows that (a) stress distributions in compressed healthy bone is (fairly) uniform, while (b) that on weak bone is concentrated on a small "stress backbone". The predicted expression for bone strength and the reliability of T 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 vibration 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 form 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 form 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, an example of which is shown in Figure 2(a). 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

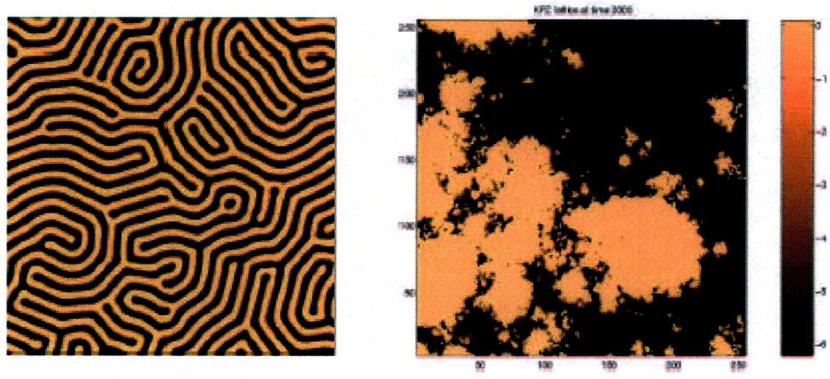


Figure 2: (a) A pattern generated by integrating a random initial state under the Swift Hohenberg equation. It consists of locally striped arrays, whose curvature is proportional to the Helmholtz operator. (b) A pattern generated by the KPZ equation. There is no local structure in these patterns. The determinant of the Hessian of the scalar field is proportional to the local curvature of contour lines.

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, see Figure 2(b). 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 2003:

1. *Title:* Current Distributions in Fused Electrical Networks
   Authors: Espinoza-Ortiz J. and **Gunaratne G.H.**
   Journal: ***Brazilian Journal of Physics*, 33:** 368 (2003)[1,2]

2. *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*** (in press) [1,2]

[1] ***Listed in the science citation index 2003***

[2] ***Listed in the science citation index-expanded 2003***

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

COMMENCEMENT: 2000

INVESTIGATORS (2003):

Nanayakkara A., *Senior Research Fellow* **(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 2002) 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 η-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

This project has produced 12 research papers and 3 research communications so far.

PROJECT OUTPUT 2003:

In 2003, we studied 1-D and 2-D pseudo Hermitian Hamiltonian systems. The Lyapunov exponents and classical phase space trajectories were used to distinguish regular motion from chaotic ones. The quantum energy level statistics and second order energy level differences were used to identify quantum signatures of classically

chaotic motion. (*Some of the results have been already published and some have been submitted for publication).*

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 using semi-classical methods. The distribution of zeros of wave functions in multidimensions are believed to contain signature of chaos in the corresponding classical system. *(Results have been submitted for publications)*

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1.* *Title:* Identification of Semi-classical Chaos in 2D *PT*-symmetric Systems
Authors: **Nanayakkara A.** and Abayaratne C.
Journal: ***Canadian Journal of Physics*, 81:** 835 (2003) [1,2]

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

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

4. *Title:* Higher-order semi-classical energy expansions for potentials with non-integer powers
Author: **Nanayakkara A.**
Journal: ***Pramana Journal of Physics*, 61:** 739 (2003) [1,2]

* ***Reported as 'in press' in Annual Report 2002***
[1] ***Listed in the science citation index in 2003***
[2] ***Listed in the science citation index-expanded in 2003***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. **Nanayakkara A.**
Classical studies of 2-D pseudo Hermitian Hamiltonian systems
1st International Workshop on Pseudo Hermitian Systems, Prauge, Czeck Republic

AWARDS:

Nanayakkara A. received Presidential Research Award for research publications (2001).

OTHER CONTRIBUTIONS:

A) Involved in designing and supervising software development for the IFS accounts division. Completed packages are
(1) Salary package
(2) Research Budget allocations
(3) Cash book

B) Two joint projects with Science Dissemination Unit at IFS were initiated:
a) Development of website for dissemination of Science in Sinhala and Tamil
b) Computer Museum

Details and the progress of these projects are given under Science Dissemination Unit report in page 74.

PROJECT: **COMPUTATIONAL MATHEMATICS AND PHYSICS**

II COMPUTER SIMULATION OF ELECTROPHYSIOLOGICAL ACTIVITIES IN HUMAN BRAIN

COMMENCEMENT: 2002 (August)

INVESTIGATORS (2003):

Nanayakkara A., *Senior Research Fellow* **(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.

PROJECT OUTPUT 2003:

In 2003 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. *(Results of this work will be submitted for publication shortly)*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. Selvarajan S. and **Nanayakkara A.**
   Effects of random weights in neural Network model for chaos in spontaneous bursting in Hippocampus slices
   19th Technical Session, Institute of Physics Sri Lanka

PROJECT: **PARTICLE PHYSICS AND QUANTUM FIELD THEORY**

COMMENCEMENT: 1997

INVESTIGATORS (2003):

Wijewardhana L.C.R., *Visiting Research Professor* **(Project Leader)**

PROGRESS ACHIEVED (*Since inception*):

During my visits to the I.F.S. I have worked on three research projects in Particle Physics and Quantum Field Theory. In 1997 and 1998 I collaborated with Anuradha Ratnaweera . We mapped out the behavior of gauge theories as a function of the number of quark flavors. Anuradha performed the required numerical computations using the computer facilities at the I.F.S. This led to a publication in Physical Review D.

During my next visits in 1998, 1999, and 2000 I worked on analyzing the properties of high density quark matter and published a paper on this. It was on the gap equation and color flavor locking in cold dense QCD with three massless flavors. We developed an effective potential method to formally analyze the stability of various phases that occur in such dense systems of hadronic matter.

In 2002 I worked on a project related to neutrino physics and also analyzed the properties of some black hole solutions. I still have not visited the IFS in 2003. Two publications resulted from the work done it 2002.

Quark matter at high density is a colour superconductor. It has been the subject of many studies for the last few years. This recent increased activity was initiated by the observation that the colour superconducting order parameter could be much larger than previously thought.

Because of asymptotic freedom, QCD becomes a weakly interacting theory at high densities. This allows one to obtain some rigorous results for dense quark matter in the asymptotic limit. Of course, from the viewpoint of phenomenology, it is desirable to have a theory valid at intermediate densities that could be produced in heavy ion collisions or could exist in nature (for example, inside neutron or quark stars). This dilemma is partially resolved by studying predictions of the theory at high densities and, then, extending their validity as far as possible to the region of interest. Notice that all the heavy quark flavors could be safely omitted from the analysis when probing the quark matter at realistic intermediate densities. As a result, one arrives at a model of dense QCD with either two ("up" and "down") or three ("up", "down" and "strange") flavors.

In 2001, we analyzed the properties of diquark states with the quantum numbers of the Nambu-Goldstone (NG) bosons, in cold dense QCD with two and three flavors.

Part of this research was carried out during a visit to the IFS. We have published a paper in Physical Review D on this subject.

We also analyzed a model field theory , namely 2+1 QCD at large densities to map out its phase structure. We derived and solved the gap equation in the leading, hard-dense loop improved, one-gluon exchange approximation . The magnitude of the order parameter is proportional to a power of the coupling constant. For an asymptotically large chemical potential, a qualitatively new (with respect to the 3+1 dimensional case) phenomenon of non-decoupling of the fermion pairing dynamics from the infrared one was observed.

PROJECT OUTPUT 2003:

Curvature Invariants of Static Einstein Spaces

During my visit in 2002 I worked on two different projects. The first involved the analysis of certain geometric properties of black holes. Black holes are gravitating objects with a singularity at the centre where the gravity is infinite . This singularity is covered by a surface called the horizon . If one falls through this surface escape is impossible. In the first project I analyzed the properties of a certain coordinate invariant scalar quantity defined in terms of the derivatives of the curvature of space. This quantity changes sign as one crosses the horizon to enter the interior of the black hole. Therefore by measuring this scalar one could determine the approach of the horizon. The research project involved the detailed analytical study of the properties of this invariant function.

NUTEV Anomaly, Neutrino Mixing and the Higgs Boson

The second project was an attempt to understand the recent results of the Neutrino at the Tevatron(NEUTEV) experiment at Fermilab in Illinois U.S.A.. In this experiment neutrinos are scattered from nuclear targets. By observing what comes out, the effective couplings of neutrinos to matter could be derived. The parameter known as the weak mixing angle is determined from this data. The value measured here seems to disagree in a statistically significant way with what is measured at CERN accelerator in Switzerland using a different process at the energy of the neutral weak gauge boson called Z. There is also another experimental anomaly involving the Z particle. Its invisible decay width, as measured at CERN seems to disagree with the predictions of the standard theory of particle physics.

We have tried to reconcile these observations by assuming that the standard neutrino mixes with a heavier neutrino, which does not feel the standard weak gauge forces. Such a mixing with a sterile neutrino would suppress the coupling of the standard neutrino to the Z particle.

The data also requires the Higgs particle, which is responsible for generating all the particle masses, to be much heavier than its currently expected mass of about 130 GeV. We are also in the process of writing another paper to explain how such neutrino mixings could naturally arise in theoretical models.

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

*1**	*Title:*	The Nutev anomaly, Neutrino mixing, and a heavy higgs
	Authors:	Loinaz W., Okamura N., Takeuchi T., and **Wijewardhana L.C.R.**
	Journal:	***Physical Review D,* 68:** 73001 (2003) [1,2]
2.	*Title:*	A curvature invariant and the local geometry of static einstein space-times
	Authors:	Mukherjee M., Esposito F.P., and **Wijewardhana L.C.R.**
	Journal:	***Journal of High Energy Physics,*** 310 (2003) [1,2]

** Reported as 'in press' in Annual Report 2002*
[1] Listed in the science citation index in 2003
[2] Listed in the science citation index-expanded in 2003

PROJECT: **CONDENSED MATTER THEORY**

COMMENCEMENT: 1999

INVESTIGATORS (2003):

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 the years 2000 and 2001, 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). Over the past few years we have also worked on magnetic properties of selected transition metal compounds (oxides, nitrides etc.) in collaboration with several research groups from UConn (Profs. J. Budnick, D. Pease, B. Sinkovic), IFS (Prof. K. Tennakone and A. Ratnaweera), Brookhaven National Laboratory (Drs. R.E. Watson and M. Weinert) and JNC Bangalore (Dr. S. Narasimhan). Some of the above work is still in progress.

PROJECT OUTPUT 2003:

This is a brief description of several projects that have been underway under my direction during the year 2003.

In order to directly evaluate the many electron effects in atoms, molecules and solids, we have completed an analytical calculation of the two electron Coulomb Green's function (with direct electron-electron interactions suppressed) with Dr. A. Kussow. This work has been submitted for publication and we are currently looking in to simple possible applications to identify its strengths.

During the year 2003, we have also worked on simplified methods to study metallic multilayered systems. Starting from a three dimensional Schrodinger equation, we have obtained a one dimensional differential equation suitable for probing confined states such as quantum well states in metallic multilayers. This work has also been submitted for publication. Work currently in progress includes Quantum Monte Carlo

(QMC) studies of nanoclusters. Using a single band Hubbard model as a test system, we are currently studying magnetic properties of simple clusters such as rings and pyramids. These QMC studies are capable of probing electron-electron interactions that are neither very weak nor very strong and there are no analytical treatments suitable for studying Hubbard model at such intermediate interaction strengths in two or higher dimensions.

PROJECT: **CONDENSED MATTER PHYSICS**

COMMENCEMENT: 1987

INVESTIGATORS (2003):

Tennakone K., *Research Professor* **(Project Leader)**
Senadeera G.K.R., *Research Fellow*
Bandaranayake K.M.P., *Research Assistant*
Jayaweeera P.V.V., *Research Assistant*
Perera V.P.S., *Research Assistant*
Pitigala P.K.D.D.P., *Research Assistant*
Seneviratne M.K.I., *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 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 150 publications international journals. The project has gained recognition has focus of activity in this field and papers published are frequently cited.

PROJECT OUTPUT 2003 :

In the year 2003 the project conducted investigation on semiconductor nanostructured systems for solar energy conversion. The emphasis has been to devise methods of extending the spectral response of dye-sensitized solar cells. A method was developed to sensitize semiconductor surfaces with several pigments avoiding mutual deactivation processes. The possibility of using polythiocyanogen as a photovoltaic material was investigated and a model photovoltaic device was fabricated. The theoretical investigation on quantum nanowire in an electrotytic medium initiated in the previous year was completed.

This project overlaps with the projects on photochemistry and solid-state chemistry.

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1.* *Title:* Dye-sensitized Photoelectrochemical and Solid-State Solar Cells
Authors: **Tennakone K., Jayaweera P.V.V.,** and **Bandaranayake P.K.M.**
Journal: ***Journal of Photochemistry and Photobiology A (Chemistry),*** **158:** 125 (2003) [1,2]

2.*† *Title:* The Effect of MgO on the Enhancement of the Efficiency in Soild-State Dye-Sensitized Photocells Fabricated with SnO_2 and CuI
Authors: **Perera V.P.S., Senadeera R., Tennakone K.,** Ito S., Kitamura T., Wada Y., and Yanagida S.
Journal: ***Bulletin of the Chemical Society of Japan,*** **76(3):** 659 (2003)[1,2]
This paper was selected as papers of special interest in the opinion of referees and the Editorial Board. (Only 07 papers were selected as selected papers).

3.* *Title:* Fabrication of Dye-sensitized Solar Cells Using Triethylamine Hydrothiocyanate as a CuI Crystal Growth Inhibitor
Authors: Kumara G.R.A., Kaneko S., Okuya M., and **Tennakone K.**
Journal: ***Langmuir, American Chemical Society,*** **18:** 10493 (2003) [1,2]

4.* *Title:* Dye-sensitization of magnesium oxide coated cadmium sulfide
Authors: **Bandaranayake P.K.M., Jayaweera P.V.V.,** and **Tennakone K.**
Journal: ***Solar Energy Materials and Solar Cells,*** **76:** 57 (2003) [1,2]

5. *Title:* Recombination process in dye-sensitized solid-state cells with CuI as the hole collector
Authors: **Perera V.P.S.** and **Tennakone K.**
Journal: ***Solar Energy Materials and Solar Cells,*** **79:** 249 (2003) [1,2]

6. *Title:* Depleted Quantum Nanowire in an electrolytic medium
Authors: **Tennakone K.** and **Jayaweera P.V.V.**
Journal: ***Superlattices and Microstructure,*** **33:** 23 (2003) [1,2]

7. *Title:* Efficient dye-sensitized photoelectrochemical cells made from nanocrystalline tin (iv) oxide-zinc oxide composite films
Authors: Kumara G.R.R.A., **Tennakone K.,** Kottegoda I.R.M., **Bandaranayake K.M.P.,** Konno A., Okuya M., Kaneko S., and Murakami K.
Journal: ***Semiconductor Science and Technology,*** **18:** 312 (2003) [1,2]

8. † *Title:* Sensitization of aluminium chloride adsorbed tin (iv) oxide nanocrystalline films with Rose Bengal
Authors: **Perera V.P.S., Senadeera G.K.R.,** and **Tennakone K.**
Journal: ***Journal of Colloid and Interface Science,*** **265:** 428 (2003) [1,2]

9. *Title:* Dye-sensitized solid-state photovoltaic cells based on dye multiplayer 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*** (in press) [1,2]

10. *Title:* Deposition of the thin films of the conducting polymer polythiocyanogen and construction of a photovoltaic device
Authors: **Perera V.P.S., Pitigala P.K.D.D.P., Bandaranayake K.M.P., Perera A.G.U.,** Hastings G. and **Tennakone K.**
Journal: ***Synthetic Metals*** (in press) [1,2]

11. *Title:* Dye-sensitized solid-state solar cells made from MgO coated TiO2 films
Authors: Kumara G.R.R.A., Kaneko S., Okuya M., and **Tennakone K.**
Journal: ***Journal of Photochemistry and Photobiology*** (in press) [1,2]

* ***Reported as 'in press' in Annual Report 2002***
† ***This also appears in the Publication List of Solid State Chemistry***
[1] ***Listed in the science citation index in 2003***
[2] ***Listed in the science citation index-expanded in 2003***

BOOKS AND MONOGRAPHS 2003:

1. *Title:* Composite semiconductor oxide nanocrystalline films for dye-sensitized solar cells, pp160-183
In the Book: Technological Application of Dye-sensitization
Author: **Tennakone K.**
Editors: Hayase S. and Fuji shinia A.
Publisher: Educational and Technological Publications, Japan

INVITED LECTURES/CONFERENCES ATTENDED IN 2003:

1. **Tennakone K.**
Nanostructured Materials for solar energy conversion
Invited lecture, International conference on Human- Friendly Materialss, University of Tokyo, August 27-28, 2003.

2. **Tennakone K.**
Nanoscience: Emersing Transdisciplinary Frontier
Invited lecture, Guest Speech, Annual Sessions of the Post Graduate Institute of Agriculture, University of Peradeniya, 21 November 2003.

3. **Tennakone K.**
Science Education to Meet the Transdisciplinary Challenge
Invited lecture, Annual Sessions of the Sri Lanka Association for the Advancement of Science, 2003.

AWARDS

Bandaranayaka K.M.P., Jayaweera P.V.V., Kottegoda I.R.M., Perea V.P.S., Senadeera G.K.R., and Tennakone K. received Presidential Research Awards for research publications (2001).

PROJECT: **PHOTOCHEMISTRY**

COMMENCEMENT: 1999

INVESTIGATORS (2003):

Bandara J., *Research Fellow* **(Project Leader)**
Tennakone K., *Research Professor*
Bandara R.G.S.J., *Volunteer Student*
Nanayakkara S.D., *Volunteer Student*
Ranasinghe S., *Volunteer Student*
Uthtamawadu P., *Volunteer Student*
Weerasinghe H.C., *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 cells applications and optimisation 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.

In last few years, several catalysts were developed for the photocatalytic degradation of pollutants based on the charge separation that are under further investigation.

Number of Publications during 1999 - 2002 in refereed international journals: 11

PROJECT OUTPUT 2003:

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). Enhanced solar cells performances were achieved for n-p junctions, however for n-i-p junctions, expected enhancement was not observed. Attempts were undertaken to understand the behaviour of n-p and n-i-p junctions.

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1. †† *Title:* Formation of Nanocrystalline Titanium Dioxide in Perfluorinated Ionomer Membrane
Authors: Liu P., **Bandara J.**, Lin Y., Elgin D., Allard L., and Sun Y.-P.
Journal: ***Langmuir,* 18:** 10398 (2002) [1,2]

2. *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*** (in press) [1,2]

3. *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*** (in press) [1,2]

†† This article did not appear in Annual Report 2002
[1] *Listed in the science citation index in 2003*
[2] *Listed in the science citation index-expanded in 2003*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. Weerasinghe H.C. and **Bandara J.**
   A compact TiO_2 barrier layer supported Solid-state dye sensitized solar cells
   Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo

AWARDS:

Bandara J., Binduhewa P., and Tennakone K. received Presidential Research Awards for research publications (2001).

PROJECT : **SOLID STATE CHEMISTRY**

COMMENCEMENT : 1999

INVESTIGATORS (2003):

Senadeera G.K.R., *Research Fellow* **(Project Leader)**
Tennakone K., *Research Professor*
Pathirathne W.M.T.C., *Research Assistant*
Perera V.P.S., *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

This Project was initiated in 1999 and current investigations are concentrated mainly on synthesis, characterization and understanding of physico-chemical proprieties of materials, such as solid polymer electrolytes, electronically conducting polymers and inorganic semiconductors (p-type) based on Cu, which have potential application in novel solid-state devices specially in solar cell devices. 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)* and
(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.

In addition to above we have successfully fabricated efficient photovoltaic device comprising with chemically attached poly 3-thiopnenyl acetic acid as the sensitizer for several nanocrystaline semiconductors,for the first time in this field. This strategy could be modified to increase the efficiencies of polymer-based solar cells above the recorded optimum values. We believe that, the methodology adopted here would lead to use conducting polymers more effectively specially in solar cells opening up the way for further studies in material science (An international patent has been applied for this work).

Apart form the above investigations, in order to prepare homogenous nanocrystalline oxide semiconducting thin films we have constructed a fully automated spray pyrolysis unit (equipment).

Total No. of articles published (since inception)

(a) *In refereed journals cited in Science Citation Index = 9*
(b) *Abstracts and conference proceedings: 12*
(c) *Conference proceedings full papers: 5*
(d) *Patents : Sri Lankan Patent No. 11982*
(e) *Presidential Awards for Research Publications in Science Citation Index- 1999, 2000, and 2001*

PROJECT OUTPUT 2003:

1. Fabrication of highly efficient polythiophene sensitized metal oxide photovoltaic cells

Poly(3-thiophenylacetic acid)-polymer sensitized photoelectrochemical cells comprising of either mesoporous TiO_2 or SnO_2-ZnO electrodes and the electrolyte consisting with redox complex (I_3^-/I^-) were fabricated and characterized. The addition of ionic liquid, 1-methyl 3-N- hexylimidazolium iodide, into the electrolyte drastically enhanced the cell performance. The cells consisting of the nanoporous TiO_2 electrodes showed the incident photon to current conversion efficiency as high as 60 % (at 430 nm) while the highest overall power conversion efficiency was ~ 2.4 % under the irradiance of 100 mW cm^{-2} (Air Mass 1.5). The overall efficiency of the cells with nanoporous SnO_2-ZnO electrodes was ~ 1.5 % under the same illumination.

2. Solid state dye sensitized solar cells using *in- situ* polymerized PEDOTs as hole conductor

All-solid state dye sensitized solar cells were fabricated using in situ photo-electrochemically polymerized poly(3,4-ethylenedioxythiophene) (PEDOT) as a hole transport phase. Absorbance spectra and photovoltaic performance of these solid cells revealed that PEDOT is more favorable than polypyrrole as a hole transport phase in terms of transparency and charge transport property. The solid cell using this PEDOT exhibited good linearity between light intensity and photocurrent density and the overall conversion efficiency of 0.53% at AM 1.5 illumination (100 mW cm^{-2}).

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1.*† *Title:* The Effect of MgO on the Enhancement of the Efficiency in Soild-State Dye-Sensitized Photocells Fabricated with SnO_2 and CuI

Authors: **Perera V.P.S., Senadeera G.K.R., Tennakone K.,** Ito S., Kitamura T., Wada Y., and Yanagida S.

Journal: ***Bulletin of the Chemical Society of Japan,* 76(3):** 659 (2003) [1,2]

This paper was selected as papers of special interest in the opinion of referees and the Editorial Board. (Only 07 papers were selected as selected papers).

2. *Title:* Fabrication of highly efficient polythiophene sensitized metal oxide photovoltaic cells
Authors: **Senadeera G.K.R.**, Nakamura K., Kitamura T., Wada Y., and Yanagida S.
Journal: ***Applied Physics Letters*, 83(26):** 5470 (2003) [1,2]

3.† *Title:* Sensitization of aluminum chloride adsorbed tin(IV) oxide nanocrystalline films with Rose Bengal
Authors: **Perera V.P.S., Senadeera G.K.R.**, and **Tennakone K.**
Journal: ***Journal of Colloid and Interface Science*, 265:** 428–431 (2003) [1,2]

4. *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*** (in press) [1,2]

* ***Reported as 'in press' in Annual Report 2002***
† ***This also appears in the Publication List in Condensed Matter Physics***
[1] ***Listed in the science citation index in 2003***
[2] ***Listed in the science citation index-expanded in 2003***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. **Senadeera G.K.R.**, Kitamura T., Wada Y., and Yanagida S.
Electrochemical deposition of polypyrrole on surface modified TiO_2 and its application as sensitizer and hole conductor in solid-state photocells
XXIst International Conference on Photochemistry, NARA, Japan, 2003 Conference Proceedings, 5P017, p559

2. **Senadeera G.K.R.**, Kobayashi S., Kanzaki T., Kitamura T., Wada Y., and Yanagida S.
Physical properties of spray painted TiO_2 films and their evaluation in solid state dye-sensitized photocells
XXIst Internatinal Conference on Photochemistry, NARA, Japan, 2003 Conference Proceedings, 2P018, p320

3. **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 sensitizer in solid state solar cells
Dye solar cells pre-symposium , (satellite conference of XXIst Int. Conference on Photochemistry) Osaka, Japan, 2003

4. Kobayashi S., Kitamura T., Ito S., Masaki T., **Senadeera G.K.R.,** Kumara G.R.A.,Konno A., Tennakone K., Wada Y., and Yanagida S.
The effect of Imidazolium salt on the hole transport property of copper iodide as a hole collector of solid -state dye dye sensitized solar cells
Meeting abstracts, The Electrochemical Society of Japan, Tokyo, Japan, 2003, 3P24. p 373.

5. Yanagida S., **Senadeera G.K. R.,** Nakamura K., Kitamura T., and Wada Y.
Electron diffusion control in dye-sensitized TiO2 solar cells: fabrication of efficient polymer-sensitized solar cells.
The 6th AIST International symposium on Photorecetion Control and Photofunctional Materials (PCPM 2003), Conference proceedings, Japan , 2003, p 42.

6. Fukuri N., Saito Y., **Senadeera G.K.R.,** Kitamura T., Wada Y., and Yanagida. S.
Application of in-situ photo-electrochemically polymerized by Poly(3, 4-ethylenedioxythiohene) to dye sensitized solar cells
Meeting abstracts, The Electrochemical Society of Japan, Tokyo, Japan, 2003, 3P22 page 372.

7. **Senadeera G.K.R.**
Dye Sensitized solar cells. A promising renewable Energy Source for the future!
Daily News, Wednesday, December 31, 2003.

INVITED LECTURES/CONFERENCES ATTENDED IN 2003:

1. **Senadeera G.K.R.**
XXIst International Conference on Photochemistry, NARA, Japan, 2003.

2. **Senadeera G.K.R.**
Dye solar cells pre-symposium, (satellite conference of XXIst Int. Conference on Photochemistry) Osaka, Japan, 2003.

3. **Senadeera G.K.R.**
The Electrochemical Society of Japan, Tokyo, Japan, 2003.

4. **Senadeera G.K.R.**
The 6th AIST International symposium on Photoreaction Control and Photofunctional Materials (PCPM 2003), Conference proceedings, Japan , 2003.

AWARDS:

1. Senadeera G.K.R. Postdoctoral Fellowship 2002-2003 (JSPS)- Japan Society for the Promotion of Sciences.

2. Senadeera G.K.R., Tennakone K., Perera V.P.S. and Jayaweera P.V.V. received Presidential Research Awards for research publications (2001).

PROJECT: **METAL COORDINATION CHEMISTRY**

COMMENCEMENT: 1999

INVESTIGATORS (2003):

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

PROJECT OUTPUT 2003 :

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, tropolone derivatives, and aminotroponimines. We are using these new ligands to prepare metal catalysts for oxo, nitrene, and carbene group transfer processes, isolate reaction intermediates, develop transition metal containing drugs, and to control photochemical processes of metal coordination compounds.

We have investigated the carbene insertion reactions catalyzed by silver complexes of fluorinated tris(pyrazolyl)borate ligands. For example, $[HB(3,5\text{-}(CF_3)_2Pz)_3]Ag(THF)$ catalyzes the carbene insertions to C-H and C-X (X = Cl, Br) bonds under remarkably mild conditions. We have also reported the synthesis of a new fluorinated tris(pyrazolyl)borate ligand featuring phenyl and trifluoromethyl substituents.

Metal pyrazolates show interesting photophysical properties. Silver(I) and copper(I) pyrazolates $[(3,5\text{-}(CF_3)_2Pz)Cu]_3$ and $[(3,5\text{-}(CF_3)_2Pz)Ag]_3$ are two such examples. They exhibit bright luminescence. They feature trimeric structures with close metal-metal interactions in the solid state. Dimers may be obtained by treating the trimers with good electron donor ligands like pyridine and triphenyl phosphine. Some of the resulting dimers show rare blue luminescence.

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1. *Title:* Syntheses of Aluminum and Zinc Alkyl Complexes of a Highly Fluorinated Tris(pyrazolyl)borate using $[HB(3,5\text{-}(CF_3)_2Pz)_3]Ag(THF)$ as the Ligand Transfer Agent
   Authors: **Dias H.V.R.** and Jin W.
   Journal: ***Inorganic Chemistry,* 42:** 5034 (2003) [1,2]

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

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

Journal: ***Polyhedron*** (in press) [1,2]*-Invited Paper for Special Issue on Scorpionates*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. **Dias H.V.R.**
   Phosphorescent trinuclear, dinuclear, and mononuclear complexes of Cu(I), Ag(I), and Au(I) with fluorinated pyrazolate ligands
   226th American Chemical Society, National Meeting, New York, United States, September 7-11, 2003

2. Diyabalanage H.V.K., **Dias H.V.R.**,. Wang Z., and Polach S.A.
   Synthesis and characterization of silver(I) and copper(I) adducts containing fluorinated pyrazolate ligands
   225th American Chemical Society, National Meeting, New Orleans, LA, United States, March 23-27, 2003

3. **Dias H.V.R.**
   Fluorinated scorpionates and their coinage metal adducts
   225th American Chemical Society, National Meeting, New Orleans, LA, United States, March 23-27, 2003

4. Lovely C.J., Browning R.G., Polach S.A., and **Dias H.V.R.**
   Carbene and nitrene transfer reactions catalyzed by fluorinated tris(pyrazolyl)borato copper(I) and silver(I) complexes
   225th American Chemical Society, National Meeting, New Orleans, LA, United States, March 23-27, 2003

5. Omary M.A., Rawashdeh-Omary M.A., **Dias H.V.R.**, Diyabalanage H.V.K.
   New classes of luminescent dinuclear and trinuclear clusters of Cu(I) and Ag(I) with fluorinated pyrazolate ligands
   225th American Chemical Society, National Meeting, New Orleans, LA, United States, March 23-27, 2003

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 (2003):

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

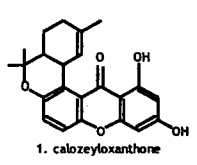
PROGRESS ACHIEVED *(Since inception):*

Prenylated xanthones isolated from *Caulophyllum* 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), a leading cause of infections in hospitals and long-term health care facilities world wide. A remarkable inhibition of *S. aureus* (MRSA and MSSA) including the control *S. aureus* NCTC 6571 were observed with calozeyloxanthone(**1**) isolated from *C. moonii*; and γ-mangostin(**2**) isolated from *G. mangostana.* Above two xanthones and α-mangostin(**3**) were also found to be active against vancomycin-resistant *Enterococci* (VRE) and vancomycin-sensitive *Enterococci* (VSE) with comparable MIC values with presently used antibiotics vancomycin and gentamicin. Further our studies showed a synergism between active natural products and presently used antibiotics against MRSA. Hence our active compounds appear to hold promise as antimicrobial agents in the treatment of infections with *S. aureeus*, including MRSA and MSSA, as well as VRE and VSE. Therefore, they should be investigated further in appropriate *in-vivo* models.

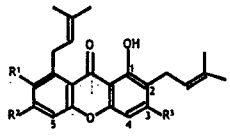
Structure-activity relationship studies of γ-mangostin(**2**), α-mangostin(**3**) and β-mangostin(**4**) indicated that free 3-hydoxy group in the active compounds is playing a major role in the activity of α-mangostin(**3**) and γ-mangostin(**2**).

cordatolide **A**(**9**) and cordatolide **B**(**10**) from *C. cordato-oblongum*, were re-isolated, and tested for anti HIV 1 RT inhibitory activity, and found to inhibit HIV-1 RT. Our experiments also revealed that relative to highly active calanolide **A**(**5**), cordatolides had an activity reduced approximately by a factor of 40. Hence, current results indicated that substituents located at position C-4 is also important for the activity. Further inhibitory activity studies were conducted using coumarins, xanthones and chromene acids isolated from different *Caulophyllum* species. Our results indicated

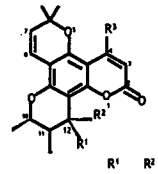
the necessity of the critical hetero-ring with three chiral centers at C-10, C-11 and C-12 and the free hydroxy group at position 12. Our results further suggested that the 2,2-dimethyl functionality by itself is biologically insignificant in conferring HIV-1 RT inhibitory activity. Therefore, observations 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)** were proposed using Mosher's concept and molecular mechanics calculations after converting them to α-methoxy-α-(trifluromethyl) phenylacetate(MTPA) esters.



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. cordatolide A	OH	H	$-CH_3$
6. cordatolide B	H	OH	$-CH_3$
7. calanolide A	OH	H	$-CH_2CH_2CH_3$

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 *Caulophyllum 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, flowing awards have been received by members of our research group.

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

2. 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.

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

5. Received Presidential Research Awards for Research Publications (1999).

PROJECT OUTPUT 2003:

Studies on anti-fungal activity of extracts from *C. thwaitesi* (root stem) against *Caladosporium* and *Aspergillus* were conducted strains using TLC bioassay and disk diffusion method respectively. However, only the methanol extract of the root stem of *C. thwaitesii* showed activity against above strains. The extract was subjected to activity guided fractionation. Column chromatography of the methanol extract gave five active fractions against *Cladosporium*. Of them three fractions were found to be active against *Aspergillus*. Further column chromatography on one of the active fractions, followed by PTLC and HPLC, gave five active principals as yellow crystalline compounds. Spectroscopic studies indicated that two of the active compounds against *Caladosporium* and *Aspergillus* as 1,3-dihydroxy-5-methoxyxanthone and 1-hydroxy-3,5-dimethoxyxanthone. In the present study, we have modified the disk diffusion method which is commonly used in bacterial studies, to suit our studies on filamentous fungi like *Aspergillus*. A number of compounds were isolated from the extracts of different plant parts of *Garcinia mangostana, Hypericum mysorense* and *C. cordato-oblongum* and their structure elucidation and bioactivity studies are in progress.

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1.* *Title:* Determination of saponins and alkaloids in *Caulophyllum thalictroides* (Blue Cohosh) by High Performance Liquid Chromatography and Evaporative Light Scattering Detection
Authors: Ganzera M., **Dharmaratne H.R.W.**, Nanayakkara N.P.D., and Khan I.A.
Journal: ***Phytochemical Analysis,*** **14:** 1 (2003) [1,2]

2. *Title:* Anxiolytic properties of *Piper methysticum* extract samples and fractions in the chick social-separation stress procedure
Authors: Feltenstein M.W., Lambdin L.C., Ganzera M., **Dharmaratne H. R.W.**, Nanayakkara W.N.P.D., Kahn I.A., and Sufka K.J.
Journal: ***Phytotherapy Research,*** **17**: 210 (2003) [1,2]

3. *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*** (in press) [2]

* ***Reported as "in press" in Annual Report 2002***
[1] ***Listed in the science citation index in 2003***
[2] ***Listed in the science citation index-expanded in 2003***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. Tennakoon S.B., Wickramasinghe C.S., Ekanayake E.W.M.A., Thevanesam V., and **Dharmaratne H.R.W.**
   Antibacterial Activity studies of *Garcinia mangostana,* against methicillin-resistant *Staphylococcus aureus* (MRSA)
   Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo.

2. **Dharmaratne H.R.W., Napagoda M.T.,** and Tennakoon S.B.
   Anti-fungal activity of xanthones from *Calophyllum thwaitesii*
   Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo.

AWARDS:

Dharmaratne H.R.W. received Presidential Research Award for research publications (2001).

PROJECT : **NATURAL PRODUCTS CHEMISTRY**
(II) Search for bioactive compounds from Sri Lankan plants as potential resources for treatment and control of diseases

COMMENCEMENT: 1992

INVESTIGATORS (2003):

Jayasinghe U.L.B., *Associate Research Professor* **(Project Leader)**
Amarasinghe N.R., *Research Assistant*
Balasooriya B.A.I.S., *Research Assistant*
Jayasooriya C.P., *Research Assistant*
Kumarihamy B.M.M., *Research Assistant*
Medawala M.M.W.S., *Research Assistant*

PROGRESS ACHIEVED *(Since inception)* :

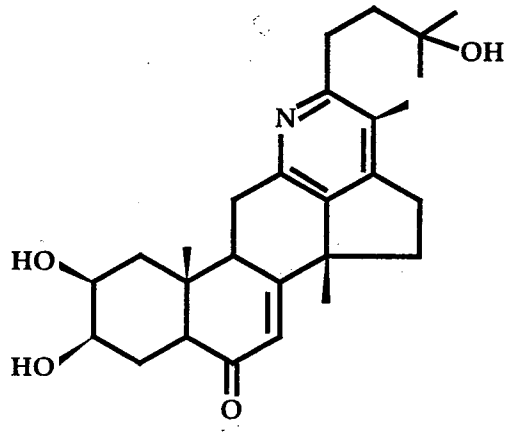
During the past ten years we have been conducting studies on bioactive ingradients of following plants: *Pometia eximia* and *Filicium decipiens* (Sapindaceae), *Sarcococca brevifolia* (Buxaceae), *Uncaria elliptica* (Rubiaceae), *Terminalia catappa* (Combretaceae), *Diploclisia glaucescens* (Menispermaceae), *Bridelia retusa* and *Ageratum conyzoides*(Euphorbiaceae). 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 Sri Lankan plants. The above work has produced 21 publications, 32 communications, two book chapters and two M. Phil. Degrees.

PROJECT OUTPUT 2003:

Minor ecdysones in the leaves of *Diploclisia glaucescens* of the family Menispermaceae were identified as 3-deoxy-1β,20-dihydroxyecdysone, makisterone A, dihydrorubrosterone and *epi*-pterosterone and the minor saponins in the leaves were identified as 3-*O*-β-D-glucopyranosyl-(1→2)-[β-D-glucopyranosyl-(1→3)]-β-D-glucopyranosyloleanolic acid 28-*O*-β-D-glucopyranosyl ester and 3-*O*-β-D-glucopyranosyl-(1→3)-[β-D-xylopyranosyl-(1→2)]-β-D-glucopyranosyl oleanolic

acid 28-*O*-β-D-glucopyranosyl ester. All these compounds are reported for the first time from the family Menispermaceae.

Chemical investigation of the non-quaternary alkaloid fraction from the methanol extract of the leaves of *D. glaucescens* furnished an unusual ecdysteroid containing pyridine ring (**1**).



(**1**)

Antifungal constituents of the stem bark of *Artocarpus nobilis* of the family Moraceae were identified as stilbene derivatives, *(E)*-4-isopentenyl-3,5,2',4'-tetra hydroxystilbeneand *(E)*-4-(3-methyl-*E*-but-1-enyl)-3,5,2',4'-tetrahydroxystilbene. Both compounds showed strong antifungal activity at 10 µg/spot against *C. cladosporioides* on TLC bio-autography method, wherein spore germinates as black zones and antifungal compounds appear as white zones and radical scavenging properties towards 2,2'-diphenyl-1-picrylhydrazyl radical (DPPH).

Antifungal constituents of the leaves of *A. nobilis* were identified as
(**1**) 2',4',4-trihydroxy-3'-geranylchalcone,
(**2**) 2',4,4'-trihydroxy-3'-[6-hydroxy-3,7-dimethyl-2(*E*),7-octadienyl]-chalcone,
(**3**) 2',4',4-trihydroxy-3'-[2-hydroxy-7-methyl-3-methylene-6-octaenyl]-chalcone,
(**4**) 2',3,4,4'-tetrahydroxy-3'-geranylchalcone,
(**5**) 2',3,4,4'-tetrahydroxy-3'-[6-hydroxy-3,7-dimethyl-2(*E*),7-octadienyl]-chalcone.

The chalcones **3** and **5** were found to be new natural products whereas **1** and **2** are reported first time from the family Moraceae. These compounds showed fungicidal activity at **1** (5 µg/spot), **2** (5 µg/spot), **3** (5 µg/spot), **4** (2µg/spot) and **5** (15µg/spot) against *Cladosporium cladosporioides* on TLC bio-autography method and radical scavenging properties towards 2,2'-diphenyl-1-picrylhydrazyl radical (DPPH).

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1.* *Title:* Bidesmosidic saponins from the fruits of *Diploclisia glaucescens*
Authors: **Jayasinghe U.L.B.,** Hara N., and Fujimoto Y.
Journal: ***Phytochemistry,* 62**: 563 (2003)[1,2]

2.* *Title:* Antifungal constituents of *Bridelia retusa*
Authors: **Jayasinghe U.L.B., Kumarihamy B.M.M.,** Jayaratne K.H.R.N., Udishani N.W.M.G., Bandara B.M.R., Hara N., and Fujimoto Y.
Journal: ***Phytochemistry,* 62**: 637 (2003)[1,2]

3.* *Title:* Nematicidal activity of some Sri Lankan plants
Authors: **Jayasinghe U.L.B., Kumarihamy B.M.M.**, Bandara A.G.D., Vasquez E.A., and Kraus W.
Journal: ***Natural Product Research,* 17**: 259 (2003)[2]

4.* *Title:* Antifeedant activity of some Sri Lankan plants
Authors: **Jayasinghe U.L.B., Kumarihamy B.M.M.**, Bandara A.G.D., Waiblinger J., and Kraus W.
Journal: ***Natural Product Research,* 17**: 5 (2003)[2]

5. *Title:* A pyridine ring-containing ecdysteroid from *Diploclisia glaucescens*
Authors: **Jayasinghe L., Jayasooriya C.P.,** Hara N., and Fujimoto Y.
Journal: ***Tetrahedron Letters,* 44**: 8769 (2003) [1,2]

6. *Title:* 2-Deoxy-5β, 20-hydroxyecdysone from the fruits of *Diploclisia glaucescens*
Authors: **Jayasinghe L., Kumarihamy B.M.M.,** Arundathie B.G.S., Dissanayake L., Hara N., and Fujimoto Y.
Journal: ***Steroids*, 68**: 447 (2003) [1,2]

7. *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*** (in press) [2]

8. *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*** (in press) [1,2]

9. *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*** (in press) [2]

**** Reported as " in press" in the Annual Research Report 2002***

[1] ***Listed in the science citation index 2003***
[2] ***Listed in the science citation index-expanded 2003***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. **Jayasinghe U.L.B.**, Puvanendran S., and Fujimoto Y.
   Antifungal stilbene derivatives from the stem bark of *Artocarpus nobilis*
   Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo

2. **Jayasinghe U.L.B.**, **Jayasooriya C.P.**, and Fujimoto Y.
   Minor ecdysteroids and saponins of the leaves of *Diploclisia glaucescens*
   Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo

3. **Jayasinghe U.L.B.**, **Balasooriya B.A.I.S.**, and Fujimoto Y.
   Steroidal and triterpenoidal saponins from the fruits of *Diploclisia glaucescens*
   Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo

4. **Jayasinghe U.L.B.**, **Balasooriya B.A.I.S.**, Padmini W.C., and Fujimoto Y.
   Antifungal chalcones from the leaves of *Artocarpus nobilis*
   Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo

POST-GRADUATE DEGREES COMPLETED IN 2003:

Name	:	Jayasooriya C.P.
Thesis Title	:	Chemistry and bioactivity of some Sri Lankan Menispermaceae and Rubiaceae.
Degree	:	M. Phil.

Degree awarded by the University of Peradeniya, 2003.

PROJECT: **BIOCHEMISTRY**

COMMENCEMENT: 1997

INVESTIGATORS (2003):

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., *Laboratory 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.

Under the project on "efficacy and toxicological studies on herbal remedies in veterinary practice in Sri Lanka", Anthelmintic activity of 13 crude plant extracts were assessed *in vitro* using larval migration inhibition(LMI) assay. Out of 13 plant extracts, *Areca catechu* fruits, *Adhatoda vasica* leaves and *Azadiractha indica* seeds have shown significant ($p<0.001$)inhibitory activity against exsheathed infective larvae (L3) of *Heamonchus contortus* and *Oesophagustomum* species. It was observed that the degree of inhibition increased significantly ($p<0.001$) with the increase of the concentrations of the crude extracts.

Above findings paved the way to five research communications, following postgraduate degree and an award.

Degree:
Rajapakse R.G.S.C., Purification and characterization of Acid Proteinases from *Nepenthes distillatoria* L., M. Phil Degree, 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 the Peradeniya University Research Sessions Purse - 2003 (Vol.8, 197 pp).

PROJECT OUTPUT 2003:

Anthelmintic property of 13 crude plant extracts were assessed *in vitro* using larval migration inhibition(LMI) assay. Out of 13 plant extracts, *Areca catechu* fruits, *Adhatoda vasica* leaves and *Azadiractha indica* seeds have shown significant ($p<0.001$)inhibitory activity against exsheathed infective larvae (L3) of *Heamonchus contortus* and *Oesophagustomum* species. It was observed that the degree of inhibition increased significantly ($p<0.001$) with the increasing concentrations of the crude extracts. Toxicity studies on active plant extracts using mice models are in progress.

Cytotoxicity and antioxident activity studies of greens and dietary supplements used in Sri Lanka are in progress.

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. **Fernando W.I.T.**, Rajapakse R.P.V.J., and **Dharmaratne H.R.W.**
   In vitro anthelmintic activity of some indigenous plant extracts against caprine gastrointestinal parasites
   Proceedings of the Peradeniya University Research Sessions Purse 2003 (Vol.8 -p.*197)*

PROJECT : **PLANT BIOTECHNOLOGY**

COMMENCEMENT: 1988

INVESTIGATORS (2003):

Ramanayake S.M.S.D., *Senior Research Fellow* **(Project Leader)**
Kovoor A., *Honorary Research Professor*
Jayasekera H., *Research Assistant*
Meemaduma V.N., *Research Assistant*
Weerawardene T.E., *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 but unlike other grasses are woody, but are different from other woody trees. Unlike other flowering plants their flowering and seeding rhythms 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 was achieved. In vitro flowering was also induced in these axillary shoots. The factors that may have contributed to in vitro flowering were studied. Callus, which exhibited an embryogenic potential, was also induced from explants of the adult clump. 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. Most of these species have not been taxonomically defined.

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 2003:

The problems that have led to recalcitrance in rhizogenesis in *D.giganteus* were identified and overcome by the use of certain treatments. These treatments were also applied to continuously proliferating shoots of two more species *D. hookeri* and *B. vulgaris* to improve their rooting and acclimatization. These protocols could be now used in commercial applications. We have given away over 500 plantlets, which were produced during experiments in these three species.

Interestingly, *Melocanna baccifera* 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.

Genetic distances computed and dendrograms denveloped 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.

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1.* *Title:* Organogenesis in callus derived from an adult giant bamboo (*Dendrocalamus giganteus* Wall. Ex Munro)
Authors: **Ramanayake S.M.S.D.** and Wanniarachchi W. A.V.R.
Journal: ***Scientia Horticulturae,* 98:** 195 (2003) [1,2]

2. *Title:* Flowering in a bamboo, *Melocanna baccifera* (Roxburgh) Kuerz ex Scheels (Bambusoidae, Poaceae)
Authors: **Ramanayake S.M.S.D.** and **Weerawardene T.E.**
Journal: ***Botanical Journal of the Linnean Society,* 143(3):** 87 (2003) [1,2]

* ***Reported as "in press" in Annual Report 2002***
[1] ***Listed in the science citation index in 2003***
[2] ***Listed in the science citation index-expanded in 2003***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. **Meemaduma V.N.** and **Ramanayake S.M.S.D.**
Tissue culture for rapid propagule production of a large- culmed bamboo
Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo.

2. **Weerawardene T.E.** and **Ramanayake S.M.S.D.**
In vitro shoot proliferation and rooting of *Bambusa vulgaris* var. vitata (Yellow bamboo)
Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo.

POST-GRADUATE DEGREES COMPLETED IN 2003:

Name	:	Wanniarachchi W.A.V.R.
Thesis Title		*In-vitro* responses of a mature clump of giant bamboo (*Dendrocalamus giganteus* Wall. ex Munro) towards micropropagation, callus culture and somatic embryogenesis.
Degree	:	M. Phil.

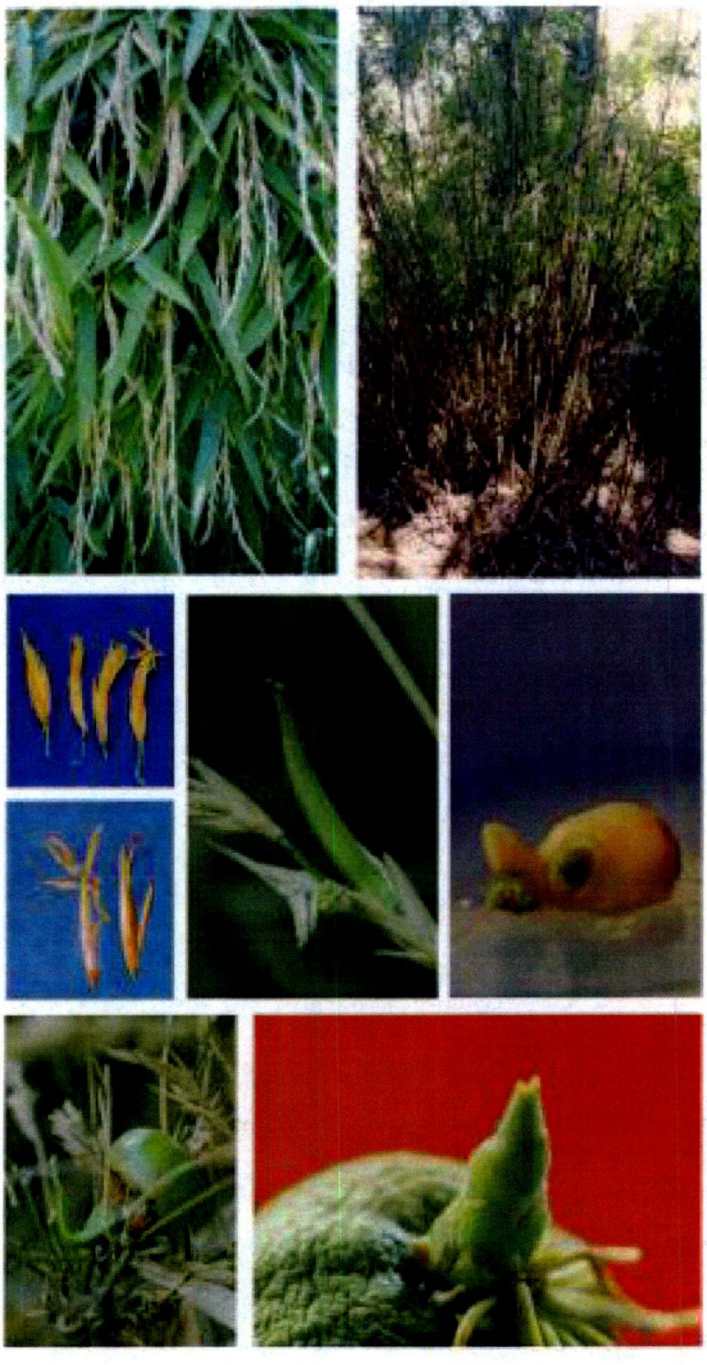
Degree awarded by the University of Sri Jayawardenepura, 2003.

AWARDS:

Ramanayake S.M.S.D., Wanniarachchi W.A.V.R., and Tennakoon T.M.A. received Presidential Research Awards for research publications (2001).

OTHERS

The Ministry of Irrrigation and Water Management and the Ministry of Environment and Forest Resources have jointly opened a tissue culture facility for propagule production of bamboo, the Riverine Bamboo Project, under the "Pavitra Ganga" Programme Phase 2. The IFS has agreed to provide the research findings of the Plant Biotechnology Project in the production of bamboo propagules by tissue culture. The Project was inaugurated on the 20th December 2003 in Mawatura, Kotmale.



Flowering in *Melocanna baccifera*

PROJECT: **PLANT REPRODUCTIVE BIOLOGY**

COMMENCEMENT: 1997

INVESTIGATORS (2003):

Iqbal M.C.M., *Senior Research Fellow* **(Project Leader)**
Kovoor A., *Honorary Research Professor*
Christie M.P., *Research Assistant*
Wijesekera K.B., *Research Assistant*

PROGRESS ACHIEVED *(Since inception):*

Androgenesis, Pollen development and Embryogenesis:

Androgenesis: Using *Datura metel* as a model plant, the role of temperature stress was investigated on the induction of pollen embryos. While previous temperature and other stress factors have been applied on varied plant species to induce androgenesis, the duration of stress application lasted from a few hours to days or even weeks. In our study we applied extreme temperature stress not only at the physiologically possible limits for cell survival, but also to a very brief duration of a total of 60 seconds. A combination of high and low temperatures were applied in immediate succession. After testing all the possible combinations of the temperatures we were able to identify a temperature combination which produced a highly significant enhancement in androgenesis in *D. metel*.

Pollen development: In our investigations on pollen development, an indigenous tree species *Gordonia dassanayakei* was found to contain pollen like cells in its anther sacs. While these had a hard exterior surface with patternings, they were apparently sterile and were found to differentiate from the parenchyma cells in the connective tissue. Such pseudopollen are not not known in the Angiosperms except in some species in the Theaceae family.

Embryogenesis: Embryogenesis in plants is studied using diploid zygotic embryos. Mutations are induced to produce defective embryos and thereby determine the genetic elements controlling embryos development. We determined similar defective embryos during in vitro androgenesis.

Secondary metabolism in vitro (in collaboration with Dr. C. Möllers, University of Göttingen): The nature of transport of the glucosinolates, a secondary metabolite, accumulated in the seeds of *Brassica* species was determined in vitro using microspore derived and zygotic embryos. Genotypes differ in their glucosinolate content and are classified into high and low glucosinolate varieties, the latter being desired. Our studies showed that the transport of glucosinolates into the embryo ocurred against a concentration gradient and was an active process. This uptake was independent of the genotype.

PROJECT OUTPUT 2003:

Embryogenesis: The defective haploid embryos from androgenesis of *D. metel* were examined histologically and found to lack meristamatic tissues in the apical and basal regions of the embryo.

Secondary embryogenesis: The induction of secondary embryos were investigated by physically wounding haploid and zygotic embryos of *D. metel*. In explants from haploid embryos, wounding caused secondary embryogenesis. In zygotic embryos wounding caused organogenesis. Further experiments are in progress to determine the dependency of the secondary embryos to the primary embryo.

Secondary embryogenesis in rice: Indica varieties of rice cultivated in Sri Lanka were screened for their ability to produce callus and subsequent regeneration to plants. the varieties showed a variation in callusing ability which was related to formation of green shoot buds. Plantlets were succesfully hardened and grown in the green house.

PUBLICATIONS IN REFERFED JOURNALS IN 2003:

1.* *Title:* Uptake and distribution of sinigrin in microspore derived embryos of *Brassica napus* L.
Authors: **Iqbal M.C.M.** and Möllers C.
Journal: ***Journal of Plant Physiology*** **160:** 961 (2003) [1,2]

2. *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*** (in press) [1,2]

** Reported as "in press" in Annual Report 2002*
[1] Listed in the science citation index in 2003
[2] Listed in the science citation index-expanded in 2003

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. **Christie M.P** , I.C. De Silva., and Iqbal M.C.M.
Plant regeneration in vitro of three Sri Lankan rice varieties (*Oryza sativa ssp. indica*).
Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo.

PROJECT: **PLANT CELL BIOLOGY**

COMMENCEMENT: 2001

INVESTIGATORS (2003):

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

PROGRESS ACHIEVED *(Since inception)*:

Scope of the project:

- Isolation and identification of cyanobacteria to ascertain their biodiversity; investigation of the biological activities of terrestrial and aquatic cyanobacterial forms.
- Development of assays for water-borne toxicants; identification of microorganisms capable of degrading toxins; characterization 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 the optimization of plant growth.
- Investigation of mechanism of antagonism, synergism and toxicity of rhizoplane and spermoplane microorganisms.

Phytoplankton : Isolations were made from samples collected from the Kandy Lake, Sri Lankan waters of the Indian Ocean, and local paddy fields on different culture media using different techniques including tube dilution and dilution plate methods.

Fresh water: Twelve members of Chlorophyceae, eight members of cyanophyceae and two of Bacillariophyceae were recorded from the samples collected from the Kandy Lake and paddy fields. These organisms occur suspended in water.

Investigations on surfaces of different substrates submerged at a depth of 1.5 m below the surface of the water in the Kandy Lake revealed the presence of chlorophytes and cyanophytes attached to the surfaces.

Genomic DNA was extracted from selected isolates using proteinase K. Three isolates showed bands, in particular one, a clear band, indicating that the extraction method was suitable for that isolate.

Seawater: Isolates from seawater were cultures on a range of media and a number of colonies were identified based on their culture characteristics. Flow cytometer measurements made at the Alfred Wegener Institute, Bremerhaven confirmed the presence of the microorganisms *Chaetoceros radicans, Chroomonas sp.*, and *Emiliana sp.*

The total DNA was extracted from the water samples for further studies.

Mycotrophy: Microorganisms were isolated from the rhizpsphere as well as rhizoplane. Dilution plate techniques were chosen to study the rhizoplane population. Soil dilution and direct soil plating techniques were used to study rhizosphere organisms. The roots were cleared with potassium hydroxide, bleached using hydrogen peroxide and stained with cotton blue. Endomycorrhizal mycelia were detected in the cortical tissues of a poaceous host.

PROJECT OUTPUT 2003:

Further studies on the organisms isolated are in progress.

Phytoplankton

Fresh water: 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 781Ra and Cya 781Rb. Agarose gel electrophoresis of the PCR amplified product of two isolates produced clear bands between 400 – 500 bp (Figure 1).

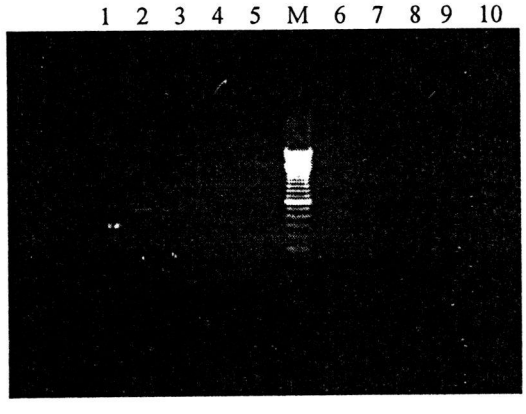


Figure 1. Agarose gel (1.5%) electrophoresis of PCR amplification products. Lanes 1-10 preparations of the isolates. Lane M, molecular marker (100bp ladder).

Studies on the biofilm community on surfaces of different substrates revealed that while some occur as single cells, others form filaments or colonies. Isolations and identifications showed that unicellular chlorophytes, and filamentous and slimy colonies of cyanophytes form the components of the biofilm.

Biomass of the microorganisms was determined by chlorophyll a quantification and samples were prepared for the determination of secondary metabolites.

Seawater: Gel electrophoresis of the PCR amplified products with the same primers gave negative results.

Cream and orange coloured colonies hydrolysed solid agar medium of one composition. Hydrolysates were carefully collected and stored at -20°C for further

studies. One of the green colonies developed green thallus-like aerial structures. Studies on the identity of these colonies are in progress.

Mycotrophy

Samples from rhizosphere and rhizoplane in different localions with different plants were studied for microorganisms. The samples from the wet zone with tea plantation and leafy vegetable plots gave positive results with different types of spores being present. Microscopic observations revealed the presence of the following organisms tentatively identified to their genus level using spore characteristics: *Acaulospora, Gigaspora* and *Glomus.*

Fungi detected in rhizoplane samples of leafy vegetables and solanaceous crops included species of *Fusarium* and *Myrothecium* while species of *Aspegillus, Eurotium* and *Penicillium* were detected predominantly in *Arachis hypogea.*

Studies on the composition of the microorganisms involved in the formation of biofilm detected along the rhizoplane of healthy *Solanum melongena* plants are being initiated.

Leaves of *Solanum melongena* from the study area showed veinal necrosis. Investigations revealed that the species of *Myrothecium* is concentrated in the rhizosphere.

The spermoplane fungi detected on incubation of the seeds of A. *hypogea* from the study area were species of *Aspergillus* and *Penicilliium.*

PROJECT: **BIOLOGICAL NITROGEN FIXATION**

COMMENCEMENT: 1986

INVESTIGATORS (2003):

Seneviratne G., *Senior Research Fellow* **(Project Leader)**
Morawaka Arachchi A.P., *Research Assistant*
Ratnayake R.R., *Research Assistant*
Sepalika J.A.H., *Research Assistant*

Assistants
Karunaratne R.C.K., *Laboratory Technician*
Karunadasa K.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 increased the 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 rhizobia polyphenol interaction, 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.

Number of publications in refereed journals: 14

PROJECT OUTPUT 2003:

1. A study on rhizobial-fungal biofilms was initiated to examine their effects on the survival and effectiveness of rhizobia under adverse conditions. The biofilms were successfully developed *in vitro*, observed and reported in a research paper. This is the first observation of such biofilms.

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 was submitted for publication.

3. An experiment was commenced 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. Additional soil analyses are being conducted.

4. Studies were initiated to examine associative nitrogen fixation in the rice rhizosphere, with special reference to *Azorhizobium caulinodans*, an efficient nitrogen fixer in the rhizosphere. Both laboratory and field studies are being conducted in this programme.

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1. *Title:* Mycelial colonization by bradyrhizobia and azorhizobia
   Authors: **Seneviratne G.** and **Jayasinghearachchi H. S.**
   Journal: ***Journal of Biosciences***, **28**: 243 (2003) [1,2]

2. *Title:* Litter controls on soil nitrous oxide emission
Authors: **Seneviratne G.** and Somapala K.L.A.
Journal: ***Current Science*, 84:** 498 (2003) [1,2]

3. *Title:* Phenolic acids: Possible agents of modifying N_2-fixing symbiosis through rhizobial alteration?
Authors: **Seneviratne G.** and **Jayasinghearachchi H. S.**
Journal: ***Plant and Soil*, 252:** 385 (2003) [1,2]

4. *Title:* Global warming and terrestrial carbon sequestration
Author: **Seneviratne G.**
Journal: ***Journal of Biosciences*, 28:** 653 (2003) [1,2]

5. *Title:* Development of eco-friendly, beneficial microbial biofilms
Author: **Seneviratne G.**
Journal: ***Current Science*, 85:** 1395 (2003) [1,2]

6. *Title:* Isotope/element fractionation during surface adsorption
Author: **Seneviratne G.** and **Nanayakkara A.**
Journal: ***American Journal of Physics (in press)*** [1,2]

[1] ***Listed in the science citation index in 2003***
[2] ***Listed in the science citation index-expanded in 2003***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. Seneviratne G.
Growth and Litterfall Trends of Global Tropical Forests
Proceedings of the Biotic Interactions in the Tropics: A Special Symposium of the British Ecological Society and The Annual Meeting of the Association for Tropical Biology and Conservation, University of Aberdeen, Scotland, UK, July (2003). (Abstract).

AWARDS:

Seneviratne G. received Presidential Research Award for research publications (2001).

PROJECT: PRIMATE BIOLOGY

COMMENCEMENT: 1983

INVESTIGATORS (2003):

Dittus W.P.J., *Honorary Senior Research Fellow* **(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.

In practice, to investigate such phenomena we have identified more than three thousand macaque individuals (living plus dead), distributed among 33 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 2003:

(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 and some were tattooed. 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.

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1. *Title:* Hematology of a natural population of toque macaques (*Macaca sinica*) at Polonnaruwa, Sri Lanka
   Authors: Ekanayake D.K., Horadagoda N.U., Sanjeevani G.K.M., Arulkanthan A., Gunatilake K.A.S., and **Dittus, W. P. J.**
   Journal: ***American Journal of Primatology***, **61**:13 (2003).

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. Ekanayake D.K., Rajapakse R.P.V.J., Dubey J.P., **Dittus W.P.J.**
   Seroprevalence of *Toxoplasma godii* infection in a natural population of toque macaques (*Macaca sinica*) at Polonnaruwa, Sri Lanka
   Proceedings of the Peradeniya University Research Sessions, Sri Lanka, October 23, 2003, 8: 207 p.p.

2. Sanjay M., Brandon-Jones D., **Dittus W.**, Eudey A., Kumar A., Singh M., Feeroz M.M., Chalise M., Priya P., Walker S.
   Status of South Asian Primates: Conservation Assessment and Management Plan (C.A.M.P.) Workshop Report, 2003.
   Zoo Outreach Organization / CBSG-South Asia: Coimbatore, India, 426pp. ISBN: 81-88722-03-0 (Paperback); 81-88722-04.

PROJECT: **ECOLOGY AND ENVIRONMENTAL BIOLOGY**

COMMENCEMENT: 1989

INVESTIGATORS (2003):

Silva E.I.L., *Associate Research Professor* **(Project Leader)**
Karunathilake K.M.B.C., *Research Assistant*
Sharaff F.F., *Research Assistant*
Athukorale N., *Laboratory Technician*
Thumpela I., *Laboratory 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 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, the trophic characteristics reservoirs in the Mahaweli basin. Limnology and water quality of the Kandalama tank were studied during pre-construction, construction and operational phase of the hotel complex to determine whether it has effects on 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 pelagic blood fish 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 Mundal 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 tropical urban water bodies. 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 structure 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 in manmade water bodies, which is currently being considered as an important aspect of land-ocean nutrient fluxes. In 2002, 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, 2002. Studies conducted on Rekawa Lagoon under European Union project on Mangrove Resilience in Coastal Zones in East India and Southwest Sri Lanka were completed for a period of two years. The results 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 2003:

In the year 2003 a major emphasis was on preparation of manuscripts for publications. A paper submitted to Current Science on Kandy Lake appeared in the Journal in October. Further a manuscript authored jointly with Dr. L.P. Jayatissa, University of Ruhuna on algal toxins in Sri Lankan reservoirs was submitted to Freshwater Biology. In addition papers were presented at two international meetings held in Bangkok (Thailand) and Vienna –Austria. A joint proposal on human impacts on coastal ecosystems was submitted to the European Union STREP Program. I was invited by ZMT Bremen to prepare a proposal with other partners of the European Union (Germany, Sweden and Belgium) and the Asian countries (India, Thailand, Indonesia and Malaysia). A collaborative research (MSc. Student thesis) conducted by a student from ZMT Bremen was awarded a master degree. Ms S. Samaradivakara submitted M Phil thesis to the University of Kelaniya while F.F. Sharaff and M. Singappuli submitted their M.Sc and M.Phil desetations to the University of Kelaniya and the University of Ruhuna respectively

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1.* *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*** (in press) [1,2]

2.* *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*** (in press) [1,2]

3. *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 Aquatic Sciences*** (in press)

4. *Title:* Emergence of a *Microcystis* bloom in an urban water body, Kandy Lake in Sri Lanka.
Authors: **Silva E.I.L**
Journal: ***Current Science,*** **5(6):** 723 (2003)

* ***Reported as "in press" in Annual Report 2002***
[1] ***Listed in the science citation index in 2003***
[2] ***Listed in the science citation index-expanded in 2003***

ABSTRACTS / CONFERENCE PROCEEDINGS IN 2003:

1. **Silva E.I.L.**
Depletion of Silica Fluxes to Indian Ocean via Sri Lankan Rivers : Dam-made Effect
Proceeding of the Symposium 2.1 in the 20th pacific Science Congress "Adaptation of Asia Pacific to Global Change Pacific Science Congress held in March 2003, Bangkok, Thailand 75- 84 pp

2. **Silva E.I.L.**
Quality of Irrigation Water in Sri Lanka – status and trends
Proceeding of the Water Professional Symposium on Water Resources Research in Sri Lanka, October 2003 PGIA University of Peradeniya35 - 48 pp

3. **Silva E.I.L.** and Sharaff F.F.
Photosynthetic characteristics of Kandy Lake - following an outbreak of cyanobacterial bloom.
Proceedings of the 9th Annual Sessions of the Sri Lanka Association for Fisheries and Aquatic Resources.

4. **Sharaff F.F.** and Silva E.I.L.
Variation of trophic determinants in Kandy Lake
Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo.

5. **Karunathilake K.M.B.C.** and **Silva E.I.L.**
Some aspects of water quality in three river systems in Sri Lanka, Maha Oya, Deduru Oya and Mi Oya.
Proceedings of the Sri Lanka Association for the Advancement of Science, 59th Annual Session, December 2003, Colombo.

6. **Silva E.I.L.**, Ekanayake M. and Karunathilake K.M.B.C.
Seasonal abundance of two species of rotifers (Brochionus calciflorus and Keratella tropica) in Kandy Lake.
Proceedings of the 9th Annual Sessions of the Sri Lanka Association for Fisheries and Aquatic Resources.

7. Weerasinghe W.M.D., Amarasinghe U.S., and **Silva E.I.L.**
Size dependant photosynthetic characteristics of phytoplankton in the Victoria reservoir.
Proceedings of the 9th Annual Sessions of the Sri Lanka Association for Fisheries and Aquatic Resources

8. **Silva E.I.L.** and Itekkott V
Damming and basin transfer on silica fluxes in rivers in Sri Lanka. International Workshop on Fluvial Ecology, November 2003 (Poster)

BOOKS AND MONOGRAPHS 2003:

1. *Title:* Factors controlling dissolved silica in tropical rivers
Author: Jennerjahn T.C., Knoppers B.A.,. de Souza W.F.L, Brunskill G.J., and **Silva E.I.L**
In the Book: "Fluxes and cycles of silicon in aquatic systems". SCOPE Series (in press).
Editors: Ittekkot V. et al

2. *Title:* Phytoplankton characteristics, trophic evolution and nutrient dynamics in an urban eutrophic lake, Kandy Lake in Sri Lanka
Author: **Silva E.I.L**
In the Book: "Tropical Eutrophic Lakes: Their Restoration and Management", Science Publishers, Inc., USA (in press)
Editors: Reddy V.

POST-GRADUATE DEGREES COMPLETED IN 2003:

Name : C. Newman
Thesis Title : International Studies in Tropical Aquatic Ecology entitled Contribution to the Yala Fisheries Management Plan Key Characteristics of the Fishery in Kinda, Sri Lanka.
Degree : M.Sc.

Degree awarded by the University of Bremen, Germany.

PROJECT: **CHEMICAL MODELING OF AQUATIC SYSTEMS**

COMMENCEMENT: 1992

INVESTIGATORS (2003):

Weerasooriya R., *Research Professor* **(Project Leader)**
Nanayakkara A., *Senior Research Fellow*
Aluthpatabendi D., *Laboratory Technician*
Makehelwala M., *Volunteer Student*
Rupasinghe S., *Volunteer 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 A. (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 the activation state of monochlorophenol (MCP)/ pyrite surface complexes
2) Calculation of essential therodynamic parameters of MCP/pyrite surface complexes
3) Reaction path modeling of 4-chlorophenol/pyrite interactions
4) Detection of reactivity sites of kaolinite for of tributyl tin (TBT) from molecular modeling methods.
5) Calibration of TBT – kaolinite interactions using mechanistic and molecular modeling methods
6) Retention of lead, cadmium and arsenic on gibbsite was quantified mechanistically.
7) Experimental evidence for site heterogeneity was obtained for gibbsite using a chemical method.
8) 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.

9) Chemical characterization of the kaolinite-water interfacial processes was completed. The proton, halide ion binding on kaolinite based on surface complexation was completed.
10) Chemical kinetic modeling for the complexation of copper-organic polymer systems was developed. Kinetic modeling of Fe-F system under acidic conditions was completed.
11) A direct method for the quantification of copper -fulvate complexation was developed.
12) SEM of Cd(II) adsorbtion on model minerals at different experimental conditions was completed.
13) 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.
14) 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).
15) 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).

PROJECT OUTPUT 2003:

1. **The As(V) adsorption onto gibbsite** Macroscopic data suggests strong As(V) bonding on gibbsite possibly via a bidendate binuclear complexation mechanism. The As(V) adsorption was quantified with the charge distribution multi site ions complexation (CD-MUSIC) model distributing the anion charge over 0- and 1- planes according to the modified Pauling's bond valence theory. In the dual-adsorbates system of As(III) and As(V), the As(III) adsorption was predicted up to pH 8 utilizing the binding constants derived for single-adsorbate data. However, with pH > 8, the modeled As(III) adsorption data is overestimated than the experimental values.

2. **Pyrite – monochlorophenol interactions:** Thermodynamic parameters of the activation state for phenol and three monochlorophenol (MCP) isomer-pyrite complexes, i.e. CP isomers used were 2-chlorophenol (2-CP), 3-chlorophenol (3-CP), 4-chlorophenol (4-CP), have been derived from the temperature dependent kinetic data. Both the pseudo 1 st order rate constants and the maximum adsorption density values, Γ_{max} have increased in the order phenol < 2-CP 3-CP < 4-CP. This suggests that the position of chlorine substituent on the aromatic ring results in an enhanced MCP affinity on pyrite surface. The activation energy (E_a), Gibbs free energy ($\Delta G^{\#}$), entropy ($\Delta S^{\#}$) and enthalpy ($\Delta H^{\#}$) of the activation stage for MCP adsorption on pyrite were calculated by Arrhenius and Eyring models. Always $\Delta H^{\#}$ values approximate to zero and $T\Delta S^{\#}$ values are positive which indicate that the activation state of MCP adsorption process is entropy-controlled, and the

observed linear dependence of $\Delta H^{\#}$ with $T\Delta S^{\#}$ signals entropy – enthalpy compensation effect of the MCP adsorption process. The pH dependence Γ_{MCP} data were quantified well by 1-pK diffused double layer model (1-pK DLM) considering following reaction stoichiometries.

Reaction stoichiometry		Log K
$>SS^{-1/3} + HL$	$= >SSHL^{-1/3}-$	-3.2
$>FeSS^{-1/3} + HL$	$= >FeSSHL^{-1/3}$	3.2
$>SSFe^{+1/3} + HL$	$= >SS$	-2.7

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1.* *Title:* On the mechanistic modelling of As (III) adsorption on gibbsite
Authors: **Weerasooriya R.**, Tobshcall H.J., **Wijesekara D.**, and Pathiratne K.A.S.
Journal: ***Chemosphere,*** **51(9):** 1001 (2003) [1,2]

2. *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*** (in Press) [1,2]

* ***Reported as "in press" in Annual Report 2002***
[1] ***Listed in the science citation index in 2003***
[2] ***Listed in the science citation index-expanded in 2003***

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. **Weerasooriya** R., Tobschall H.J.
Modeling geochemical fate of As(V) under simulated natural conditions
Summer School of Goundwater Modeling using PMWIN 3, University of Bremen, Germany (poster presentation)

2. **Weerasooriya** R., Tobshcall H.J., Makehelwala S.A.M.
Monochlorophenol and pyrite interfacial interactions at the transition state
Annual Sessions of the School of Applied Geology, University of Erlangen-Nurenberg Germany (poster presentation)

3. **Weerasooriya R.**
Molecular modelling innovations – in situ detection of copper at pCu 10 using selective ion electrode
Departmentt of Mineralogy and Geology, Universitat Erlangen Germany, Annual Colloquia 2003 (invited lecture)

4. Miendaner M.M., **Weerasooriya R.,** and Tobschall H.J.
Adsorption of arsenate, arsenite, molybdate, phosphate and selenate on gibbsite *Workshop Forschungszentrum, Karlsruhe, March 24 th – 25 th 2004 Germany*

AWARDS:

Weerasooriya R. and Aluthpatabendi D. received Presidential Research Awards for research publications (2001).

PROJECT: **STRUCTURAL GEOLOGY**

COMMENCEMENT: 1995

INVESTIGATORS (2003):

Kehelpannala K.V.W., *Senior Research Fellow* **(Project Leader)**
Kleinschrodt R., *Visiting Associate Professor*
Kröner A., *Visiting Senior Professor*
Yoshida M., *Visiting Senior Professor*
Ratnayake R.M.J.W.K., *Research Assistant*
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) (vi) 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 this period were published in refereed journals (15 papers), in proceeding volumes (14 papers, including two chapters in the Second Edition of the National Atlas of Sri Lanka) and in the form of abstracts (23).

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 international symposia and workshops held in India, China and Japan to present some of the results of the project. 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. In addition, the Project Leader is the Sri Lankan convenor of two international projects of the International Geological Correlation Programme, viz., UNESCO-IGCP 368 on "Proterozoic Events in East Gondwana" and UNESCO-IGCP 440 on "Rodinia Assembly and Breakup".

PROJECT OUTPUT 2003:

During the year 2003, the work started in the previous year was continued.

1. The study of geology and structure in the Vijayan Complex that seems to be part of an old island arc was continued. The field data so far collected show that this arc related Vijayan Complex has suffered at least four ductile deformations at mid crustal levels. (This work is being continued).

2. Preliminary geological and structural studies along the boundary shear zones of the major crustal blocks in Sri Lanka were carried out. (This work is being continued).

4. XRD and DTA studies of different textural varieties of vein graphite from Sri Lanka were carried out at the Shizuoka University, Japan by the Project Leader.

3. The major landslides occurred in the Ratnapura district on 17 May 2003 were studied in detail with a view to understand their mechanisms. In this study landslides took place in the Kalawana-Potupitiya, Nivitigala, Kahawatta and Elapatha areas were selected for the detailed investigation.

   The research so far carried out led us to establish that two major types of landslides occurred in the Ratnapura district. These are: (1) landslides involving colluvium deposits overlying crystalline bedrocks and (2) landslides involving weathered bedrocks. It was found that the second type of landslides is more dangerous than the first type and has caused the most serious damages to both life and property. (This work is being carried out).

PUBLICATIONS IN REFEREED JOURNALS IN 2003:

1.* *Title:* Multistage graphite precipitation through protracted fluid flow in sheared metagranitoid, Digana, Sri Lanka: evidence from stable isotopes

Authors: Binu-Lal S.S., **Kehelpannala K.V.W.,** Satish-Kumar M., and Wada H.

Journal: ***Chemical Geology,*** **197:** 253 (2003) [1,2]

2.* *Title:* Ca. 750-1100 Ma magmatic events and Grenville-age deformation in Sri Lanka: relevance for Rodinia supercontinent formation and dispersal, and Gondwana amalgamation
Authors: **Kröner A., Kehelpannala K.V.W.,** and Hegner H.
Journal: ***Journal of Asian Earth Sciences,* 22:** 279 (2003)[2]

3. *Title:* Recent advances on the study of the Proterozoic geological evolution of Sri Lanka - International Symposium and Field Workshop of IGCP-440 and LEGENDS Proposal.
Authors: **Yoshida M.** and **Kehelpannala K.V.W.**
Journal: ***Episodes,* 26:** 320 (2003) [1,2]

4. *Title:* Structural Evolution of the middle to lower crust in Sri Lanka - A Synthesis
Author: **Kehelpannala K.V.W.**
Journal: ***Journal of the Geological Society of Sri Lanka*** (in press)

5. *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*** (in press) [1,2]

6. *Title:* Diversity in the position of Sri Lanka within the Gondwanaland ensemble
Authors: **Yoshida M.,** Tani Y., Rajesh H.M., and Santosh M.
Journal: ***Journal of the Geological Society of Sri Lanka*** (in press)

**** Reported as "in press" in Annual Report 2002***
[1] Listed in the science citation index in 2003
[2] Listed in the science citation index-expanded in 2003

BOOKS AND MONOGRAPHS IN 2003:

1. *Title:* Geology
Author: **Kehelpannala K.V.W.**
In the Book: (Section 3.1)-***National Atlas of Sri Lanka,*** Second Edition
Editors: Survey Department of Sri Lanka (in press).

2. *Title:* Structure and Tectonics
Author: **Kehelpannala K.V.W.**
In the Book: (Section 3.3)- ***National Atlas of Sri Lanka,*** Second Edition
Editors: Survey Department of Sri Lanka (in press).

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2003:

1. **Kehelpannala K.V.W.**
   Sri Lankan type vein graphite: An indicator of mantle carbon
   19th Annual Technical Sessions of Geological Society of Sri Lanka, , Colombo, 1-2. (2003)

2. **Kröner A., Kehelpannala K.V.W.,** and Hegner E.
   880-1000 Ma magmatic event(s) in the Wanni Complex of Sri Lanka and speculations on their relevance for Rodinia and Gondwana supercontinent formation. In: Kehelpannala, K.V.W. (ed.)
   Proceedings of the IGCP-440 and LEGENDS International Symposium and Field Workshop on "The Role of Sri Lanka in Rodinia and Gondwana Assemble and Break-up", Centenary Publication, Geological Survey and Mines Bureau, Sri Lanka, 32.

3. **Kehelpannala, K.V.W.** (ed.), 2003.
   Proceedings of the IGCP-440 and LEGENDS International Symposium and Field Workshop on "The Role of Sri Lanka in Rodinia and Gondwana Assemble and Break-up", Centenary Publication, Geological Survey and Mines Bureau, Sri Lanka, 78 pp.

4. Osanai Y., Sajeev K., Owada M., **Kehelpannala K.V.W.,** Prame W.K.B.N., Nakano N., and Jayatileke S.
   Evolution of the highest-grade metamorphic rocks from central Highland Complex, Sri Lanka. In: Kehelpannala K.V.W. (ed.),
   Proceedings of the IGCP-440 and LEGENDS International Symposium and Field Workshop on "The Role of Sri Lanka in Rodinia and Gondwana Assemble and Break-up", Centenary Publication, Geological Survey and Mines Bureau, Sri Lanka, 25-31.

5. **Kehelpannala K.V.W.** and Prame W.K.B.N. (eds.)
   IGCP-440 and LEGENDS Initiative International Symposium and Field Workshop on "The Role of Sri Lanka in Rodinia and Gondwana Assembly and Break-up", Excursion Guide, Centenary Publication, Geological Survey and Mines Bureau, Sri Lanka, (in press).

6. **Kehelpannala K.V.W., Kröner A.,** and Prame W.K.B.N.
   Grenville-age metaigneous and metapelitic rocks and late Pan-African, shear zone-controlled metasomatism in the Wanni Complex of Sri Lanka. In: Kehelpannala, K.V.W. and Prame, W.K.B.N. (eds.), 2003.
   IGCP-440 and LEGENDS Initiative International Symposium and Field Workshop on "The Role of Sri Lanka in Rodinia and Gondwana Assembly and Break-up", Excursion Guide, Centenary Publication, Geological Survey and Mines Bureau, Sri Lanka (in press).

7. **Kehelpannala K.V.W.** and **Kröner A.**
   Grenville-age calc-alkaline magmatism and deformation, and Pan-African metamorphism, deformation and migmatization in central Sri Lanka. In: Kehelpannala, K.V.W. and Prame, W.K.B.N. (eds.), 2003.

IGCP-440 and LEGENDS Initiative International Symposium and Field Workshop on "The Role of Sri Lanka in Rodinia and Gondwana Assembly and Break-up", Excursion Guide, Centenary Publication, Geological Survey and Mines Bureau, Sri Lanka (in press).

8. **Kehelpannala K.V.W.** and Kröner A.
Grenville-age magmatism and late Pan-African post-metamorphic, fluid-controlled in-situ charnockitzaion in the Wanni Complex, Sri Lanka. In: Kehelpannala, K.V.W. and Prame, W.K.B.N. (eds.), 2003.
IGCP-440 and LEGENDS Initiative International Symposium and Field Workshop on "The Role of Sri Lanka in Rodinia and Gondwana Assembly and Break-up", Excursion Guide, Centenary Publication, Geological Survey and Mines Bureau, Sri Lanka (in press).

9. **Kehelpannala K.V.W.** and Kröner A.
The role of the Palaeoproterozoic Highland Complex in the Rodinia-Gondwana puzzle, Grenville-age magmatic rocks of the Vijayan Complex, and deformation and migmatization at their Pan-African collisional zone related to Gondwana accretion. In: Kehelpannala, K.V.W. and Prame, W.K.B.N. (eds.), 2003.
IGCP-440 and LEGENDS Initiative International Symposium and Field Workshop on "The Role of Sri Lanka in Rodinia and Gondwana Assembly and Break-up", Excursion Guide, Centenary Publication, Geological Survey and Mines Bureau, Sri Lanka (in press).

INVITED LECTURES/CONFERENCES ATTENDED IN 2003:

1.* **Kehelpannala K.V.W.**
Migmatization of Layered Basic Complex in Central Sri Lanka
Invited lecture, Chiba University, Chiba, Japan. (26.11.2002)

2.* **Kehelpannala K.V.W.**
Structure, Metamorphism and Metasomatism of the Lower Crustal Rocks in Sri Lanka
Invited lecture, Yokohama National University, Yokohama, Japan. (27.11.2002)

3.* **Kehelpannala K.V.W.**
Geological and Structural Evolution of the Proterozoic Basement of Sri Lanka
Invited lecture, National Institute for Polar Research, Tokyo, Japan (28.11.2002)

4.* **Kehelpannala K.V.W.**
Sri Lankan-Type Vein Graphite: An Indicator of Mantle Carbon?
Invited lecture, Shizuoka University, Shizuoka, Japan.(02.12.2002)

5.* **Kehelpannala K.V.W.**

Lecture 1- Geological Evolution of the Lower Crust in a Gondwana Fragment

Lecture 2- Origin of Sri Lankan-type Vein Graphite

Invited lectures, University of Okayama, Okayama, Japan. (05.12.2002)

6.* **Kehelpannala K.V.W.**

A Traverse Through the Middle to Lower Crust in Sri Lanka

Invited lecture, University of Kochi, Kochi, Japan (09.12.2002)

7.* **Kehelpannala K.V.W.**

Vein Graphite

Conducted a Special Seminar for Graduate Students at the Shizuoka University, Shizuoka, Japan. (13.12.2002)

8.* **Kehelpannala K.V.W.**

Crustal Units in Sri Lanka and their Significance in Gondwana Reconstruction

Delivered a lecture at the Shizuoka University, Shizuoka, Japan. (16.12.2002)

9. **Kehelpannala K.V.W.**

What Caused Landslides in the Ratnapura District

Delivered a public lecture at the Institute of Fundamental Studies, Kandy. (10.06.2003)

10. **Kehelpannala K.V.W.**

The Origin and Structure of the Earth

Invited lecture for school teachers, Uva Provinces at the Faculty of Applied Sciences, Sabaragamuwa Province, Buttala - organized by the Geological Society of Sri Lanka and the Ministry of Education, Uva Province. (11.07.2003)

11. **Kehelpannala K.V.W.**

Internal Structure of the Earth

Lecture for school children – School Science Programme, Institute of Fundamental Studies, Kandy. (23.08.2003)

12. **Kehelpannala K.V.W.**

Landslides in Hardrock Terrains – Examples from Sri Lanka

Delivered an invited lecture at SLAAS, Colombo – Seminar on "Landslides and Their Mitigation" organized by the Geological Society of Sri Lanka and SLAAS -Section D. (19.09.2003)

* ***Not included in the Annual Research Report 2002.***

OTHERS:

A. SYMPOSIUMS AND WORKSHOPS CONDUCTED IN 2003

1. **Kehelpannala K.V.W.**
   Organized and conducted an international symposium and a filed workshop on "The Role of Sri Lanka in Rodinia and Gondwana Assembly and Break- up" and on the LEGENDS Proposal for a N-S Seismic Traverse Across
   Southern India and Sri Lanka" - 29th March – 3rd April 2003, at the Institute of Fundamental Studies, Kandy.

2. **Kehelpannala K.V.W.**
   Conducted a workshop on "Landslides in the Potupitiya area"organized by the Kalawana Divisional Secretariat for government officers and local villagers at the Potupitiya Maha Vidyalaya, Potupitiya on 31. 07. 2003.

3. **Kehelpannala K.V.W.**
   Conducted a workshop on "Landslides in the Kalawana area" organized by the Kalawana Divisional Secretariat for government officers and local villagers at Kalawana on 01. 08. 2003.

4. **Kehelpannala K.V.W.**
   Conducted a workshop on "Landslides in the Ratnapura District" organized by the Chief Secretary, Sabaragamuwa Province for Divisional Secretaries, Engineers, Development Officers and Gramasevakers at the Sabaragamuwa Provincial Council, Ratnapura on 23. 09. 2003.

B. SYMPOSIUMS PROCEEDINGS:

1. *Title:* Report of the international symposium of IGCP-440 and LEGENDS proposal in Sri Lanka, March-April 2003
   Authors: **Yoshida M.**, Osanai Y., Owada M., Nakano N., and **Kehelpannala K.V.W.**
   Journal: ***Gondwana Research**, Volume 6, 939-941 (2003).*

2. *Title:* Observations in the Proterozoic Geology of Sri Lanka: IGCP-440 Filed Workshop, March-April 2003
   Author: **Yoshida M.**
   Journal: ***Gondwana Research**, Volume 6, 939-941 (2003).*

PROJECT: CHEMICAL COMPOSITION OF ARCHAEOLOGICAL METALLIC OBJECTS

COMMENCEMENT: 2003

INVESTIGATORS (2003):

Prof. Bandaranayake S.
Mr. Thanthilage A.
Ms. Aluthbatapendi D.

PROJECT OUTPUT:

A collaborative project with Post-graduate Institute of Archaeology was initiated in the year 2003. An extensive series of chemical analysis of samples were constructed using atomic absorption spectrophotometric facilities at the IFS.

SCIENCE DISSEMINATION

Tilakaratne C.T.K. and Sellam S.

Research colloquia, public lectures and 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 IFS and researchers in other institutions to visitors who come to IFS on short notice.

Public lectures: These promote the public understanding of science.

(B) Awareness and educational programmes for students

School Science Programme:
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.

Special lectures were given by the IFS Scientists at Maliyadeva College Kurunegala, Dharmaraja College Kandy, Mahamaya Girls' College Kandy, and Teldeniya Maha Vidyalaya, Teldeniya.

Lab visits : Lab visits were organised for undergraduate students and for School children. Special lecture on IFS and its activities were prepared in advance to enable these students to understand the IFS activities better.

(C) Publication and reports

Annual research report for the year 2002 was compiled.

Reprints of research papers published in scientific journals in 2001 by IFS scientists were compiled in a book form.

A document about the IFS research performance from 1995-2002 was prepared. This document includes all the details about the project outputs, project funds/expenditure and index of research performance in Sri Lanka.

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) Web site for dissemination of Science in Sinhala and Tamil

This is developed by Science Dissemination Unit jointly with Dr. Asiri Nanayakkara. During 2003, major part of the development of electronic science glossaries has been completed. Database files for Botany, Mathematics, and Physics (for English-Sinhala) has been created. Remaining data base files (English-Tamil, English-Sinhala) are being constructed.

(E) Computer Museum

In order to give information about the evolution of computers for the last 21 years, a computer museum was built using outdated old generation computers and peripherals such as printers, dumb monitors etc.

RESEARCH MEETINGS, PUBLIC LECTURES, RESEARCH COLLOQUIA AND SPECIAL LECTURES

RESEARCH MEETINGS

31.03.2003 **Chemistry and Bioactivity of some Sri Lankan Menispermaceae and Rubiaceae**
Ms. C.P. Jayasooriya, Research Assistant, IFS

02.04.2003 **Genetic diversity and relationships within a population of *dendrocalamus giganteus* and *Ochlandra stridula* using random amplified polymorphic dna (Rapds)**
Ms. V.N. Meemaduma, Research Assistant, IFS

25.06.2003 **Land-use change, soil organic matter, clay and nutrient availability**
Ms. R.R. Ratnayake, Research Assistant, IFS

12.08.2003 ***Garcinia mangostana* - Chemistry and Bio-activity**
Ms. K.G.N.P. Piyasena, Research Assistant, IFS

03.09.2003 **Search for anti fungal compounds from Sri Lankan flora**
Ms. M.T. Napagoda, Research Assistant, IFS

17.09.2003 **Halides for improving conductivity of polycrystalline p-CuSCN films**
Mr. V.P.S. Perera, Research Assistant, IFS

02.10.2003 **Phytochemical approach to herbal remedies in ethnoveterinary medicine**
Ms. W.I.T. Fernando, Research Assistant, IFS

15.10.2003 **Dye-sensitized solid-state photovoltaic cells based on dye multilayer nanostructure**
Mr.P.K.D.D.P. Pitigala, Research Assistant, IFS

PUBLIC LECTURES

28.03.2003 **Seismic Imaging as a tool in understanding crustal structure – experience in India and strategies for studies in Sri Lanka**
Dr. P.R. Reddy, Emeritus Scientist, National Geophysical Research Institute, India

28.05.2003 **Natural Terrace Development and Soil Fertility Gradient in SALT: A Sri Lankan Experience**
Dr. H.M.S.P. M. Weerasinghe, Senior Lecturer, Department of Botany, University of Peradeniya

10.06.2003 **What caused land slides in the Ratnapura District?**
Dr. K.V.W. Kehelpannala, Senior Research Fellow, IFS

11.06.2003 **Aluminium**
Prof. K. Tennakone, Director, IFS

30.07.2003 **Fuel cell technologies and Hydrogen economy**
Dr. V. Yogendran, Director, Powertech-BC-Hydro, Canada

29.10.2003 **Honeybees of Sri Lanka: Their Biology and Management**
Dr. R.W.K. Punchihewa, Head, Department of Agricultural Biology, University of Ruhuna

RESEARCH COLLOQUIA AND SPECIAL LECTURE

03.01.2003 **Blackholes in Brane World**
Mr. C. Sahabandu, Graduate Student, University of Cincinnati, USA .

11.07.2003 **1st Principle's Statistical Mechanics**
Prof. G.W. Fernando, University of Connecticut, USA and Visiting Research Professor, IFS

WORKSHOPS AND SEMINARS

29.03.2003 International Symposium and Field Workshop in Sri Lanka on "The role of Sri Lanka in Rodinia and Gondwana Assembly and Break-up".

29.08.2003 to 30.08.2003 Training programme for IFS staff on Finance and Administration.

EDUCATIONAL VISIT

06.03.2003	Undergraduate students from Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka.
04.04.2003	Technical Team from Star Building Quart (Pvt) Ltd.,Colombo.
09.04.2003	Students from Sri Salananda Maha Vidyalaya, Bulathkohupitiya.
03.07.2003	Undergraduate students from Department of Chemical Engineering,University of Moratuwa.
15.07.2003	Students from Ladies' College, Colombo 7.
08.08.2003	Students from Prince of Wales College, Moratuwa
13.08.2003	Students from Southlands College, Galle.
24.09.2003	Students from Sabaragamuwa University.
01.10.2003	Undergraduate students from Department of Botany, University of Peradeniya.
19.12.2003	Postgraduate students from Postgraduate Institute of Science, Peradeniya.

SPECIAL PROGRAMME FOR SCHOOL CHILDREN

04.07.2003	Lecture on **Universe through Physist's Eye** delivered on Astroday at Mahamaya Girls' College, Kandy. *Dr. A. Nanayakkara, Senior Research Fellow, IFS*
16.09.2003	**Lecture** on **Preservation of the Ozone Layer** at Teldeniya Maha Vidyalaya. *Dr. G. Seneviratne, Senior Research Fellow, IFS*

SCHOOL SCIENCE PROGRAMME 2003
21st August - 23rd August 2003

21st August

Geometry, Space and Time
Prof. K. Tennakone

Wonders in Chemistry
Dr. J. Bandara

22nd August	**What is the world made of? What holds it together?** *Dr. A. Nanayakkara*
	A Star is born *Mr. I. Medagangoda*
	A Beginning to Astronomy *Dr. A.I. Kankanamge*
23rd August	**Global Warming** *Dr. G. Seneviratne*
	Internal Structure of the Earth *Dr. K.V. W. Kehelpannala*

RESEARCH STAFF 2003

Kovoor A.	Honorary Research Professor
Kröner A.	Honorary Research Professor
Tennakone K.	Research Professor, Director/IFS
Weerasooriya S.V.R.	Research Professor
Queisser H.J.	Distinguished Visiting Research Professor
Yoshida M.	Honorary Visiting Research Professor
Dias H.V.R.	Visiting Research Professor
Fernando G.W.	Visiting Research Professor
Gunaratne G.H.	Visiting Research Professor
Perera U.	Visiting Research Professor
Wijewardena L.C.R.	Visiting Research Professor
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Jayasinghe J.H.M.U.L.B.	Associate Research Professor
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Silva E.I.L.	Associate Research Professor
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Iqbal M.C.M.	Senior Research Fellow
Kehelpannala K.V.W.	Senior Research Fellow
Nanayakkara A.	Senior Research Fellow
Ramanayake S.M.S.D.	Senior Research Fellow
Senevirathne P.R.G.	Senior Research Fellow
Bandara J.	Research Fellow
Jeyanandarajah P.	Research Fellow
Senadeera G.K.R.	Research Fellow
Wanigasekera W.M.A.P.	Visiting Scientist

RESEARCH ASSISTANTS

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Project Leaders are responsible for the authenticity of information they have provided to compile this document.