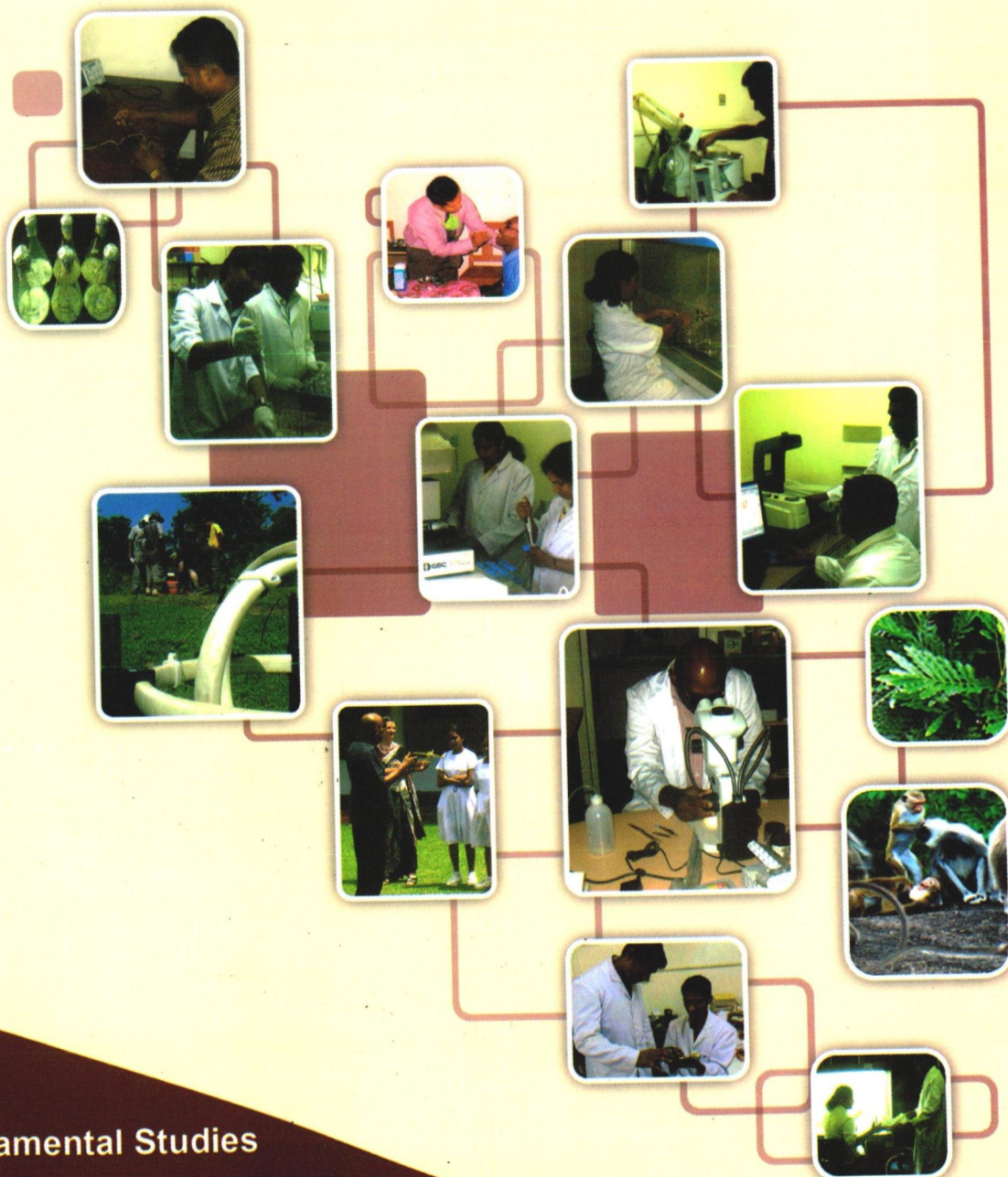
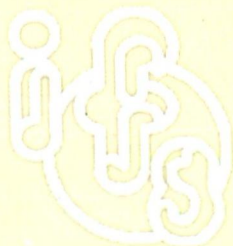


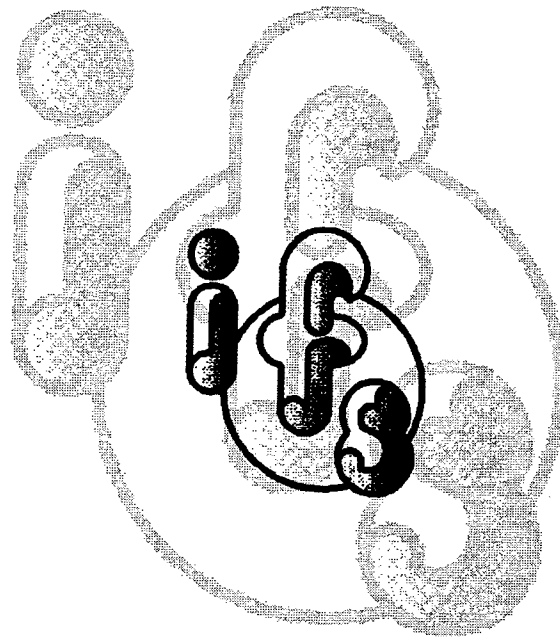
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Annual Review 2010



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Annual Review 2010
Institute of Fundamental Studies

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Hantana Road
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Sri Lanka

2010

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BOARD OF GOVERNORS

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Dr. D.N. Magana-Arachchi, Institute of Fundamental Studies, Kandy

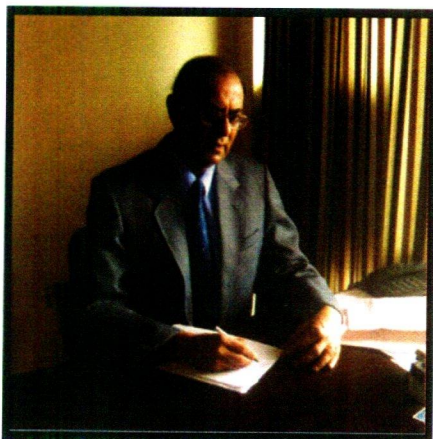
Prof. N.S. Kumar, Institute of Fundamental Studies, Kandy

Dr. N.D. Subasinghe, Institute of Fundamental Studies, Kandy

Dr. R. Rathnayake, Institute of Fundamental Studies, Kandy

Dr. M. Vithanage, Institute of Fundamental Studies, Kandy

MESSAGE FROM THE DIRECTOR



It is with great pleasure that I write this message on the occasion of the 2010 Annual Review of the Institute of Fundamental Studies. As a leading scientific research institute in Sri Lanka, the IFS scientists have contributed significantly towards the development and dissemination of science both nationally and internationally. The institute has emerged as a leading international research organization in the field of solar cells and it is to the credit of our research scientists that such an honour has been bestowed on Sri Lanka. The emerging fields of nanoscience and nanotechnology will form the thrust of future research at the IFS and it is our aim to contribute significantly towards the national development of Sri Lanka through basic research.

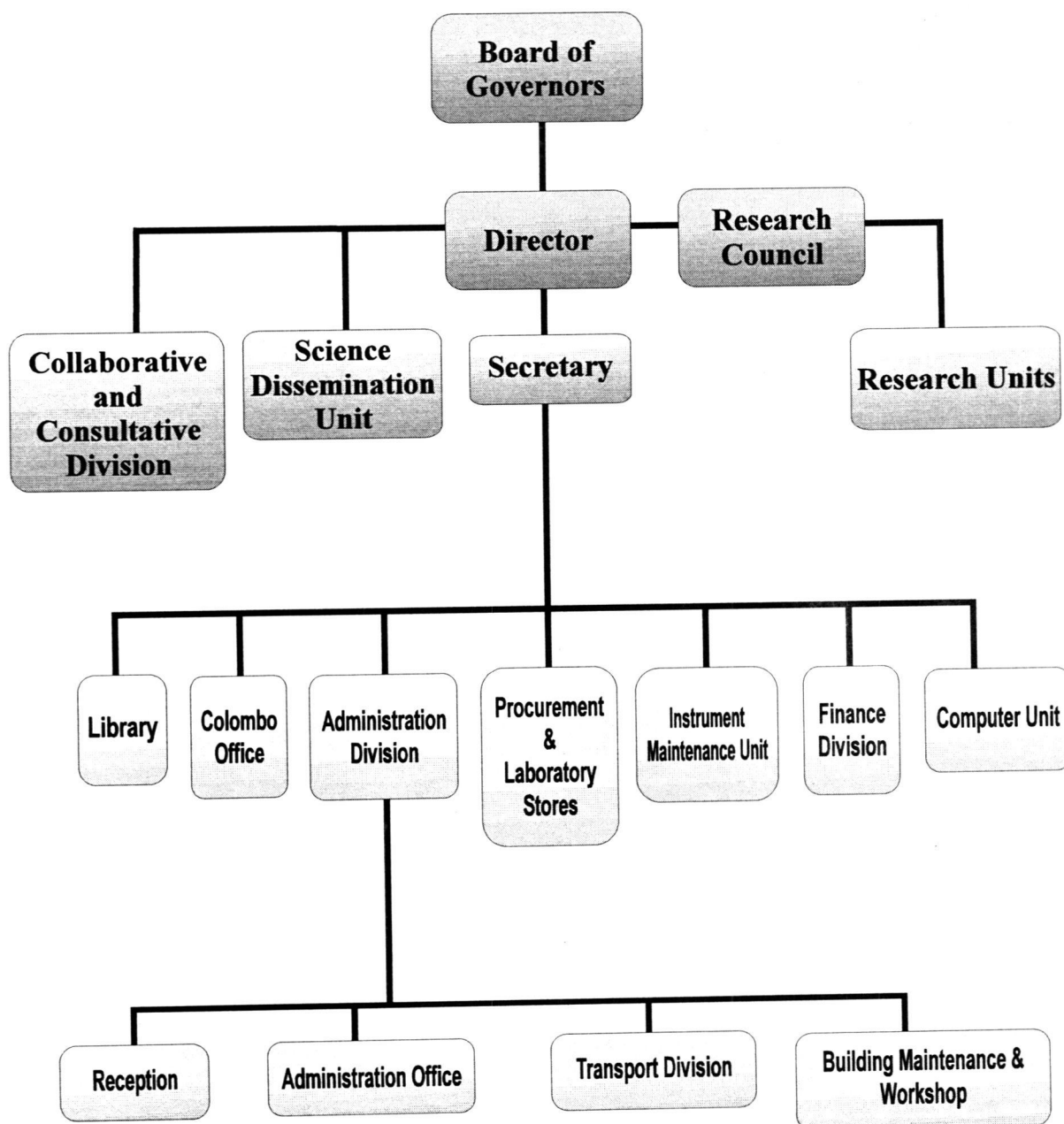
Even as a relatively small institute with a team of 14 scientists, we have been able to strengthen our collaboration with other scientific organizations in the country and this spirit of collaboration and co-operation will be strengthened in the years to come.

I consider it my pleasant duty to thank the new Minister of Technology and Research Hon. Pavithra Wanniarachchi, the Deputy Minister Hon. Faizer Mustapha and the energetic Secretary of the Ministry, Mrs. Dhara Wijayathilake for the support rendered to the Institute of Fundamental Studies.

I wish the 2010 IFS Annual Review all success.

Prof. C.B. Dissanayake
Director
Institute of Fundamental Studies

Organisational Chart



GENERAL INTRODUCTION

Prof. C.B. Disanayake, Director, IFS

The Institute of Fundamental Studies (IFS) is a unique research institute in Sri Lanka. It is the only institute in the country which has as its main objectives initiating, promoting and conducting basic research in mathematics, physical and chemical sciences, life sciences and philosophy taken in the broadest sense.

The IFS was established in 1981 by an Act of the Parliament of Sri Lanka. The IFS is administered by a Board of Governors, with His Excellency the President as the Chairman and comprising of eleven members. The Research Council, chaired by the Director of the IFS, serves as an advisory body on scientific matters to the Board.

With greater emphasis on national development particularly after the end of the war in the country, the need for scientific research with a clear impact on the welfare and standard of living of citizens of Sri Lanka became imperative. His Excellency the President had made this clear in 2007 when he addressed the Board members of the IFS. He commented thus *"I would like to stress the importance of IFS engaging itself in activities which has an impact on the masses. We are utilizing resources coming from the people and the impact of research should also be made visible"*.

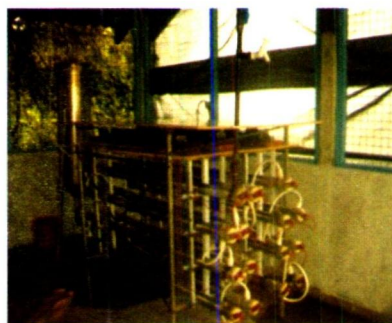
Accordingly, the Institute of Fundamental Studies changed its policy towards contributing to national goals through basic research. Scientists who opted to carry out purely fundamental and theoretical studies however, were also granted opportunities to further their aims and objectives. In a general sense, it is our mission to carry out that type of research which is of a primary and fundamental nature but with a clear purpose of having an impact on national development. This shift of policy has already paid dividends and it is indeed encouraging to note the greater interest shown by the private sector in our research. Buoyed by the enthusiasm of the scientists and the greater recognition of our research efforts by the scientific community, both local and international, a Consultative and Collaborative Division (CCD) was set up to work in liaison with the state and private sector corporate bodies, universities etc. for commissioned and collaborative research.

The IFS scientists have performed creditably during the past year and in spite of financial constraints they have been able to achieve significant results in their investigations. The search for geothermal energy and development of biofertilizer biofilms stand out as major developments. With the rapid escalation of kidney diseases and fluorosis in the dry zone of Sri Lanka, mainly in the north central regions, scientific research into the quality of groundwater in these regions has become a national priority. The IFS has been involved in the groundwater quality mapping of fluoride-rich regions and has also produced a fluoride and water hardness filter using the electro-coagulation method.

The Science Dissemination Unit (SDU) has, during the past year, carried out excellent programmes, mainly workshops and seminars for a large number of teachers and students from several districts. Tamil has not been neglected and the IFS has conducted several teacher training programmes for the Tamil science teachers. The research collaboration with universities is better than ever before and a large number of students from universities have been given opportunities to be trained at the IFS, under the able guidance of IFS scientists. The Institute of Fundamental Studies will continue to be in the forefront of scientific research in Sri Lanka and it is indeed heartening to note the extreme enthusiasm and the support given to us by our new Minister of Technology and Research Hon. Pavithra Wanniarachchi and the Deputy Minister Mr. Faizer Mustapha.



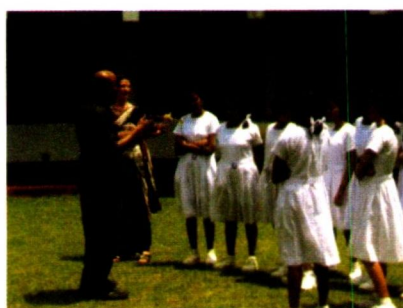
Search for geothermal energy



Electro-coagulation unit



The first issue of a trilingual popular science magazine
SCIENTIA was launched in October, 2010.



Dissemination of Science Training Programmes



From left to right

Prof. J.M.S. Bandara, Dr. C.T.K. Tilakaratne, Dr. D. Magana-Arachchi, Prof. M.A.K.L. Dissanayake, Mr. K.T. Waisundara, Prof. G.K.R. Senadeera, Prof. S.A. Kulasooriya, Mr. J. Padmasiri, Prof. N.S. Kumar, Dr. S.P. Benjamin, Prof. U.L.B. Jayasinghe, Dr. W. Dittus, Prof. C.B. Dissanayake (Director), Prof. T.R. Herat, Dr. D. Subasinghe, Dr. M. S. Vithanage, Dr. R.R. Ratnayake, Prof. P.R.G. Seneviratne, Prof. A. Nanyakkara, Dr. M.C. M. Iqbal

GENERAL REVIEW AND SUMMARIES

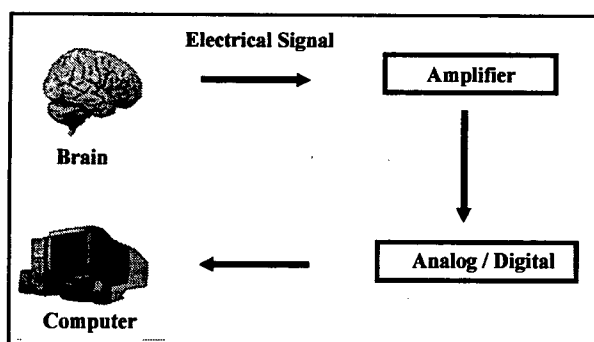
7.1 ARTIFICIAL INTELLIGENCE AND APPLIED ELECTRONICS

Project Leader: Prof. Asiri Nanayakkara, Research Professor

7.1.1 Brain Computer Interface Project

Introduction

The Brain Computer Interface (BCI) project aims at building high performance hardware and software system, which provides communication link between the human brain and a computer. Using such a system, a person can control any equipment or interact with outside world using his or her thoughts alone without any physical involvement.



BCI systems are especially invaluable for patients who suffer from severe motor impairments (late stage of Amyotrophic Lateral Sclerosis (ALS), severe cerebral palsy, head trauma, and spinal injuries). This way, patients who are with severe physical disabilities can control equipments such as wheel chairs, Televisions, etc and communicate with computer voice in his or her native language (Sinhala, Tamil or English). BCI research group at Institute of Fundamental Studies (IFS) is mainly interested in constructing a BCI system based on Electroencephalography (EEG).

Objectives and progress

Since EEG equipment is usually quite expensive and most people living in Sri Lanka cannot afford them, one of the aims of the project is to design and develop low cost software and hardware needed for BCI. The other aim is to develop a real time BCI system which could be used by severely physically disable people in Sri Lanka. This includes development of new techniques to extract thoughts from EEG signals and carrying out activities according to thoughts. Research and development work of BCI have been carried out during last two years in two main avenues;

- (1) Development of new methods and software system to recognize thoughts from individuals and control external devices according to recognized thoughts.

- (2) Design and construction of low cost BCI hardware including EEG amplifiers, recording electrodes, etc

Results

- (1) New set of thoughts which can be recognized by existing signal processing methods was developed. It was found that these new thoughts can be recognized more effectively compared to the motor movement mental tasks which are the most heavily used set of thoughts in the BCI systems.
- (2) Complete BCI software system was developed for offline analysis of EEG signals and classifying the thoughts associated with them.
- (3) A low cost amplifier was designed and constructed with eight channels, each of which can be software programmable to be used as an EEG, ECG (Electrocardiogram), EMG (Electromyogram), or EOG (Electrooculogram) channel.
- (4) One of the research assistants in this project obtained an MPhil degree from Postgraduate Institute of Science at University of Peradeniya.

Human resource development:

M. Phil. Zahmeeth Sakkaff MPhil 2010 University of Peradeniya

7.1.2 Sinhala Language Based Artificial Intelligence Project

Introduction

Individuals with speech disabilities (non-vocal) need an effective way of communication with the general public who may or may not understand sign languages. Hence, it is useful for a person with speech disabilities (PSD) to have a portable electronic system which can produce Sinhala speech, according to input received from him or her. If the PSD can use a keypad or can control a glove type device, Sinhala speech system with a keypad or an electronic glove is suitable. For an individual who cannot speak and has lost muscle control in his or her hands or arms, EMG signals produced by working muscles in any part of his or her body can be used as input.

Objectives and progress

In this project we are developing a portable electronic speech system based on microcontrollers which can

produce Sinhala speech, according to the input received from the disable person. For disable persons who can use their arms or hands, a keypad or an electronic glove is provided as input devices while for individuals who cannot speak and have lost muscle control in their hands and arms, a speech system can be used with electrical signals produced by working muscles in any part of their.

- (1) Development of a keypad based Sinhala speech system. First, a PC based system will be developed and later, stand alone portable Sinhala speech systems will be developed using microcontrollers.
- (2) Development of a hand glove based Sinhala speech system. First, a PC based system will be developed and later, stand alone portable Sinhala speech systems will be developed using microcontrollers.
- (3) For the people who cannot control the speech system with their fingers, EMG based Sinhala speech system will be developed. For this purpose EMG amplifier will also be designed and developed.

- (4) A Speech recognition system with a limited vocabulary to control a Personal Computer will be constructed for individuals who can speak Sinhala but cannot use a computer keyboard due to physical disabilities.

Results:

- (1) Sinhala speech database using Sinhala Phonemes was developed and computer software was developed for converting Sinhala text to Sinhala speech.
- (2) Electronic glove was designed and developed which can be used not only with speech devices but also with any multimedia system.
- (3) EMG amplifier was designed and constructed

Human resource development:

Dammika Wijetunga M. Phil (registered), Faculty of Engineering, University of Peradeniya

7.2 BIOFUEL RESEARCH PROJECT

Project Leader: Dr. Renuka Ratnayake, Reserach Fellow

7.2.1 Biofilm based biofuel production using invasive weeds as the substrate.

The biofuel research project commenced activities on October 2009. The project intends to develop biofilmed microorganisms for the production of cellulosic biofuels using invasive weeds as the substrate. A biofilm is a special community of microorganisms where a variety of microorganisms such as fungi, bacteria, actinomycetes etc. live adhered to each other and/or a solid surface. Biofilms have a potential to improve efficiency of biofuel production by combining the three processes delignification, saccharification and fermentation in a single reactor.

In Sri Lanka biofuels can be produced domestically, reducing oil import bills and dependence on countries which possess fossil fuel deposits. Ability to produce biofuels from invasive weeds may provide adequate amount of low cost raw materials while reducing its threat to the biodiversity. The project findings so far have proved that *Panicum maximum* (Sinh. Mana) is a suitable substrate for biofuel formation using microbial biofilms. Further experiments are continuing.

Research Expertise: Prof.S.A. Kulasooriya
Human Resource Development

Research Assistant, IFS- Registered for M.Phil degree
Under graduate student, Uwa Wellassa University-
thesis submitted

M.Sc. Student from PGIS: research completed
Trainees:

Graduate Student from Bangalore University
Pre University Research assistant

7.2.2 Soil carbon sequestration to mitigate global warming

The project commenced on August 2010. This project studies the mechanisms of organic matter stabilization, changes of carbon stocks and the role of microorganisms in soil carbon sequestration. Soil is known as a carbon sink, which means that it can absorb and hold carbon for years without releasing it as carbon dioxide in to the atmosphere. If the soil is properly managed, the carbon content will increase gradually. In this project agricultural plantations, forest plantations and home garden systems will be studied for the potential of soil carbon sequestration and methods to improve their carbon sequestration. Various land-use parameters results in very rapid decline of soil organic matter as a result of different

management practices. Therefore in this project we will be looking at the possibilities of ensuring maximum retention of carbon in the soil.

7.2.3 Potential of soil carbon sequestration in home garden systems

Home gardens are reported to be the best-developed agroforestry system in Sri Lanka. They are rich in plant diversity and have been ranked top among all manmade agroecosystems for their high biological diversity after natural forests. These multispecies plant associations are speculated to have high carbon sequestration potential due to their forest-like structure and composition, particularly in accumulating carbon in the soil. After the decline of natural forests these diverse gardens will be the last remnants of land that are capable of capturing carbon dioxide from the environment.

In this study we quantify total storage of organic carbon in home garden systems of different species compositions. The overall objective of this research is to study the effects of home garden systems of different species composition on soil carbon sequestration and its contribution to the total carbon budget of the country. We will also be looking at the long-term socio-economic implications of management practices which aim to increase carbon sequestration in order to better understand the effects of climate change.

The research findings will be utilized to develop a model home garden that maintain a high-output and a maximum carbon sequestration potential.

7.2.4 Soil carbon sequestration in forest plantations

Forests and forest soil can store about 20 to 100 times more carbon per hectare than croplands. Forest tree plantations have been shown to be an effective way to enhance carbon sequestration. Changes in microbial community composition and function in response to different stages of forest plantation may play an important role in determining rates of carbon sequestration in the soil.

The objectives of this research are to quantify the effects of forest plantation on soil carbon sequestration and its contribution to the total carbon budget of the country and to study the soil microbial contribution to carbon sequestration. The research is

still at its initial stages and results are pending. Finlay Tea Estates and Uwa Wellassa University are the collaborators of this research.

Human Resource Development

D. Wasalamuni, Research Assistant, IFS- Registered for a M.Phil degree

S. Premathilake, Lecturer, Uwa Wellassa University-registered for Ph.D.

R. Jayawardena, M.Sc. Student, PGIA

Conference proceedings

Ratnayake, R.R., Seneviratne, G., Kullasooriya, S.A., (2009). Soil C sequestration in labile organic and stable mineral fractions of natural forests and cultivated lands in Sri Lanka. In *Proceedings of the International Symposium on Organic matter Dynamics; Land use, management and global change*, Colorado, USA, 6-9 July 2009.

Visits

R. R. Ratnayake visited the National Renewable Energy Laboratory, Colorado, USA, July 2009

7.2.5 Research Summary

BIOFILM BASED BIOFUEL PRODUCTION USING INVASIVE WEEDS AS THE SUBSTRATE

Damitha Gunathilaka, Renuka Ratnayake, & S.A. Kulasooriya

Introduction

The development of alternatives to non-renewable fossil fuels is an urgent global priority as they would be exhausted soon and their use aggravates environmental pollution and global warming. Development of fuels from biomass is widely accepted as a timely strategy towards energy independence from fossil fuels.

Terrestrial and water plants contain lignocellulosic materials and once these lignocellulosic materials break into simple sugars, fermentation of sugars into biofuels can be done by using micro organisms. However in cellulosic biofuel production the major problem is that the crystalline structure of cellulose makes it difficult to hydrolyze into simple sugars. Development of microbial consortia or microbial enzymes which can be used in this purpose is a major concern of biofuel researchers.

A biofilm is a special community of microorganisms where a variety of microorganisms such as fungi, bacteria, actinomycetes etc. live adhered to each other and/or a solid surface. The conversion process of lignocellulose materials into biofuel is expensive as the process involves three steps: pretreatment, saccharification, and product recovery. Biofilms have a potential to improve efficiency of these processes by combining delignification, saccharification, fermentation, and separation in a single reactor (Seneviratne et al. 2008).

Aims and Objectives

The main objective of this project is to produce biofilms that are capable of:

*Breaking down lignocelluloses of invasive weeds into simple sugars

*Processing sugars in to biofuel. Invasive weeds used are *Eupatorium odoratum*, *Panicum maximum*, *Lantana camara*, *Mimosa pigra*

Most of the countries try to reduce the dependence on

fossil fuels by introducing biofuels as a substituent. In Sri Lanka biofuels can be grown and processed domestically, reducing oil import bills and dependence on countries which possess fossil fuel deposits. Biofuels reduce the risk of green house effect and air pollution. It is a renewable energy source and consumes carbon dioxide while they (plants used in biofuel production) grow offsetting the CO₂ emission while burning. Ability to produce biofuels from invasive weeds may provide adequate amount of low cost raw materials while reducing its threat to the biodiversity.

Results

All-together 230 organisms of cellulose utilizing bacteria, fungi and actinomycetes from different locations have been isolated and stocked. Fifteen fungal-bacterial biofilms that are effective on cellulose degradation have been developed. However the effectivity and persistence under different substrate conditions have to be tested. The simple sugar production by one biofilm, the individual bacterium and the fungus (which was used in the production of that particular fungal-bacterial biofilm) has been studied. The study was carried out in both plant substrate (*Panicum maximum* – an invasive weed) and in commercially available cellulose. Result up to now show that there is an improvement with the biofilm microorganisms over microorganisms.

7.2.6 Research summary

SOIL CARBON SEQUESTRATION: TO MITIGATE GLOBAL WARMING

Dailini Wasalamuni and Renuka Ratnayake

Introduction

To mitigate the risk of global climate change, many analyses have focused on reducing emissions of carbon dioxide and other greenhouse gases. Much less attention has been given to the potential for sequestering significant amounts of carbon as an alternative means of offsetting the effect of future emissions on GHG concentrations in the atmosphere. Via carbon sequestration, carbon can be stored for hundreds to thousands of years in carbon pools reducing the threat of global warming. From the three major pools of carbon, soils sequester higher amount of carbon, which is about 1,500 gigatons of carbon while terrestrial plants and the atmosphere store about 560 and 720 gigatons of C respectively (Six *et al.* 2006).

Carbon sequestration is now becoming a global trend. After the suggestion of trading carbon, at Kyoto protocol, in 1997, total annual emissions are capped in many countries and shortfalls are to be covered through trading, using carbon credits. So CO₂ is now turning in to a product that can be marketed, and help countries to earn billions of foreign exchange which encourage countries that emit less and sequester more carbon. As a developing country, with less emission Sri Lanka's economy can be upgraded by sequestering more carbon in the soil.

A thorough understanding about the underlying processes and mechanisms controlling soil C levels is necessary for increasing the potential for soils to sequester C. Soil microbial communities are key regulators of soil carbon dynamics. They are the pioneers of shifting organic carbon to more stable fractions in soil. Identification and understanding the roles of those microorganisms will be useful in the management of C sequestration potential of soil. If properly managed, the humus level of the soil and the resulting carbon content will increase gradually.

Aims and objectives

- * Quantify the effects of forest plantations, agricultural plantations and home garden systems on soil C sequestration
 - * Estimate their contribution to the total C budget of the country
 - * Soil microbial contribution for carbon sequestration.
- The resulting data will also be used in the future CDM activities.

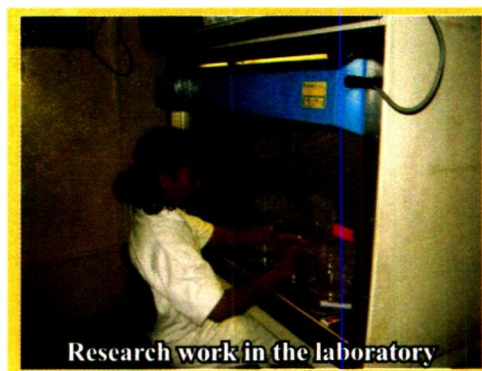
Results

Field trials have been set out in Eucalyptus plantations and tea plantations belonging to different age groups in Uwa province and home garden systems in the central province. Sampling and analysis are continuing. Results are still pending.

References

Seneviratne, G., Zavahir, J.S., Bandara, W.M.M.S. and Weerasekara, M.L.M.A.W. (2008). Fungal-bacterial biofilms: their development for novel biotechnological applications. (World J microb BioE) 24:739-743.

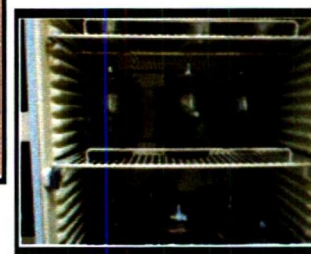
Six, J., Frey, S.D., Thiet, K. And Batten, K.M. (2006) Bacterial and Fungal contributions to carbon sequestration in agroecosystems, (Soi Sci Soc Am J) 70 :555-569.



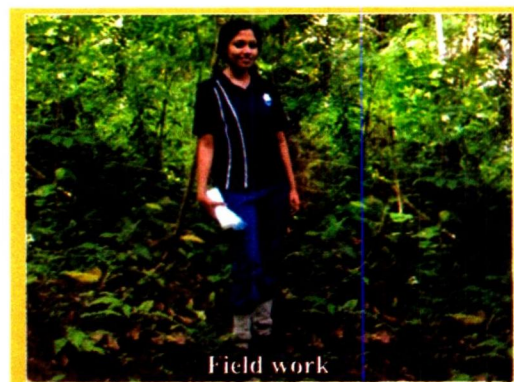
Research work in the laboratory



(10x100x5)
Biofilm



Incubation experiment



Field work

7.3 CELL BIOLOGY PROJECT

Project leader: Dr. D.N.Magana - Arachchi , Research Fellow

The Cell Biology project was initiated in 2004 December with research conducted on cyanobacteria and since 2009 research is focussed on cyanobacteria and tuberculosis with research projects which explore the resources available, improvement of human welfare and contribution to national development.

7.3.1 Molecular Phylogenetics of Cyanobacterial species in Sri Lanka

Objectives and progress of the project: Commenced in 2004 December, the objectives of the study are to isolate and identify cyanobacteria to ascertain their biodiversity, to characterize the isolated cyanobacteria using morphological characters, to study their phylogeny and to develop assays for waterborne toxicants. Cyanobacteria represent a major untapped reservoir of biodiversity for potential discovery of new biotechnological products. The present study provides information on the enormous diversity and wealth of cyanobacterial species in Sri Lanka to explore their hidden wealth and potential for human welfare. In many eutrophic fresh water lakes, cyanobacteria frequently form toxic blooms which are a potential health risk. Determination of the toxigenicity of the cyanobacteria gives a warning of potential toxicity development and permits early intervention to avoid health problems. The monitoring of toxicity levels in water bodies, similar to other countries, is a must to minimize the potential health risks.

Presently 44 isolates from 14 genera and 17 isolates from two orders were identified revealing the vast diversity of cyanobacteria which could be used in biotechnological processes. A simple and rapid molecular technique was developed to detect the presence of a cyanotoxin (microcystin) in water bodies enabling the early detection of potential toxin producing cyanobacteria, and their efficient management before a bloom occurs throughout water bodies in Sri Lanka.

Collaborations

Dr. N.V.Chandrasekharan, Department of Chemistry, University of Colombo

Human Resource Development

Ms.R. P. Wanigatunge, RA – M.Phil (Registered for a PhD-2010) University of Colombo

7.3.2 Cyanotoxins and Chronic Kidney Disease (CKDu)

Objectives and progress of the project: This project commenced in 2009 December with the objectives of isolation, molecular characterization of *toxin producing Cyindrospermopsis* strains with special reference to the North Central Province where a chronic kidney disease with unknown etiology is prevalent (CKDu)) and to identify whether cyanotoxins are a risk factor for this disease in Sri Lanka. Among the cyanotoxins, microcystin and cylindrospermopsin are the predominant toxins in freshwater lakes and have been implicated in several cases of animal and human poisoning by damaging the liver and the kidney. Further, more recently, an epidemic of CKDu prevailing in the North Central Province and its related areas of Sri Lanka has increased the concern of cyanobacteria in Sri Lankan water bodies. However, the incidence, etiology, and demography are largely unknown and only few studies have been published. The reason might be due to the combined effect of chemicals and biological compounds, probably cyanotoxins, present in water sources in these areas. Therefore, identification of such cyanobacteria in water sources would meet our long term objective of providing new, rapid molecular monitoring capability for tracking cyanotoxin producing cyanobacteria. According to our findings, tanks in Anuradhapura (Nuwara wewa, Tissa wewa and Kala wewa), has a vast distribution of cyanobacterial species Microcystis, Cyindrospermopsis, Phormidium, Lyngbya etc with toxin generating ability and it could be a major risk factor for the CKDu in the dry zone. Data collection was completed from 200 CKDu patients at Girandurukotte Kidney Dialysis Clinic and blood and urine samples and water samples from different water sources (well water, streams, paddy etc) were also collected from CKDu patients for further analysis.

Collaborations

Dr. Thilak Abeysekara, Consultant Physician, Dialysis Unit, General Hospital, Kandy
Dr. N.V.Chandrasekharan, Department of Chemistry, University of Colombo

Scientific expertise

Prof. S.A. Kulasooriya

Human Resource Development

Ms. H. M. Liyanage, RA – Registered for an M.Phil, University of Colombo

Ms. C. Prematilake, Volunteer RA

7.3.3 Study on *Mycobacterium* strains Multidrug-resistant Tuberculosis

Objectives and progress of the project: This project commenced in 2007 January with the objective of developing a simple, rapid and inexpensive assay based on PCR methodology for direct detection of Multidrug-resistant (MDR) strains from tuberculosis (TB) patient's clinical samples. MDR TB is an emerging problem of great importance to public health, with higher mortality rates than drug-sensitive TB. One of the most important challenges in the control of TB is a rapid diagnosis of cases and the optimization of anti-tuberculous treatment, mainly to prevent the development of resistance and the dissemination of resistant strains. Presently, TB patients in Sri Lanka are provided free treatment from Government hospitals. If chronic cases could be prevented and/or cured this could lead to considerable savings in the national economy. It is now widely appreciated that better health has an important role in reducing poverty and promoting economic growth.

To determine a detailed picture of TB epidemiology in Kandy, a total of 190 sputum specimens obtained from TB patients, are being studied. Upto now, 1.4% of the *M. tuberculosis*/*M. tuberculosis* complex isolates from first visit patients showed isoniazid resistance and 23.3% were resistant to rifampin and 1.4% were multi-drug resistant. During this period gene sequencing was completed for 54 strains of *M. tuberculosis* and nucleotide sequences obtained from Gene Sequencing for *inhA*, *katG* and *rpoB* genes were deposited in the GenBank.

Grant: NRC No. 07-47. Rs. 4,233,000.00

Collaborations

Prof. V. Thevanesam, Department of Microbiology, Faculty of Medicine, University of Peradeniya.

Dr. D. Medagedara, Respiratory Unit, General Hospital, Kandy

Human Resource Development

Dr. V. Ambalavanar Registered for an M.Phil, University of Peradeniya

Mr. B.A. De Silva, RA.

7.3.4 DNA fingerprinting of TB

Objectives and progress of the project: This project commenced in 2007 January with the objectives, to characterize the *M. tuberculosis* strains by DNA finger printing and to determine the use of DNA finger printing (RFLP and Spoligotyping) in the study of person to person transmission of pulmonary TB among the general population and their effect on the epidemiology of TB. It is widely accepted that TB is one of the most important threats to human health on a global scale. Infection with *M. tuberculosis* complex causes the greatest number of deaths by a single infection agent. Molecular Epidemiology is a field that has emerged largely from the integration of molecular biology, clinical medicine, statistics and epidemiology. In essence, molecular epidemiology focuses on the role of genetic and environmental risk factors, at the molecular, cellular or biochemical level in disease etiology and distribution among populations.

RFLP analysis showed that majority of the circulating *M. tuberculosis* strains in Kandy belong to a single family, but the degree of DNA polymorphism among strains was high. Spoligotyping of 110 *M. tuberculosis* isolates revealed a total of 24 families including the nine major families of TB. This was the first study in Sri Lanka in which both the RFLP pattern of *M. tuberculosis* strains and the spoligotyping in a population has been examined. In most countries the RFLP and spoligotyping patterns are recorded from each tuberculosis patient and data are deposited for future reference in treatment and here we have demonstrated the feasibility of establishing molecular typing methods in Sri Lanka especially in RFLP & spoligotyping without using any commercial kits.

Grant: NSF No. RG/2006/HS/07 - Rs. 1,616,387.00

Collaborations

Prof. V. Thevanesam, Department of Microbiology, Faculty of Medicine, University of Peradeniya.

Dr. D. Medagedara, Respiratory Unit, General Hospital, Kandy

7.3.5 A rapid method to detect non-tuberculosis mycobacteria

Objectives and progress of the project: This project commenced in 2009 April with the objective of developing an assay to differentiate tuberculosis and non-tuberculosis mycobacterium (NTM) in patients using DNA methodology. Atypical mycobacterium is one of the common infections, which affect immuno suppressive patients and the patients with pre-existing lung diseases. Now we are labeling those patients as sputum negative patients. Because of this, we need exact information regarding the atypical

mycobacterium prevalence and sensitivity patterns in this country. In preliminary investigations from 120 bronchoscopy samples collected from patients attending the Central Chest Clinic, and General Hospital, Kandy, 36 (30%) were suffering from non tuberculosis mycobacterium diseases.

Collaborations

Dr. D. Medagedara, Respiratory Unit,
General Hospital, Kandy

Human Resource Development:

Ms. U. Karunatatne, Volunteer RA

7.3.6 Research summary

CYANOBACTERIA, ITS SECONDARY METABOLITES AND CKDU

R.P. Wanigatunge, H.M. Liyanage, D. N. Magana-Arachchi and S.A. Kulasooriya

Introduction

Cyanobacteria are prokaryotes (single-celled organisms) often referred to as "blue-green algae." While most algae are eukaryotic (multi-celled), cyanobacteria is the only exception. Cyanobacteria obtain their energy through photosynthesis. They exist as unicellular, colonial and or in filamentous forms. Cyanobacteria are very old, with some fossils dating back almost 4 billion years (Precambrian era), making them among the oldest things in the fossil record. They played a key role in increasing the amount of oxygen in the Earth's atmosphere.

Certain cyanobacteria notably *Aphanizomenon flos-aquae* and *Arthrospira platensis* (*Spirulina*) are commercially important and sold as food. Recent research have also hinted at their possible application in the generation of Clean and Green Energy via converting sunlight directly into electricity. Currently efforts are underway to commercialize algae-based fuels such as diesel, gasoline and jet fuel. Certain cyanobacteria produce cyanotoxins including anatoxin - aplysiatoxin, cylindrospermopsin, domoic acid, microcystin LR, nodularin (from *Nodularia*), or saxitoxin. Sometimes a mass-reproduction of cyanobacteria results in algal blooms. These toxins can be neurotoxins, hepatotoxins, cytotoxins, and endotoxins, and can be toxic and dangerous to humans and animals. Several cases of human poisoning have been documented but a lack of knowledge prevents an accurate assessment of the risks.

Concern about cyanobacterial blooms in fresh waters in Sri Lanka has also grown in recent years due to numerous reasons. These include: frequent recordings of cyanobacterial blooms, suspected fish kills by these blooms, problems created by blooms formed in aesthetic water bodies in the capital and other cities. In addition to these, a patchy distribution of thick cyanobacterial scum in irrigation water bodies in Sri Lanka is commonly observed, particularly in the dry season. However, studies of the distribution and bloom formation of cyanobacteria in fresh waters of Sri Lanka are scarce, despite the fact that waters in most of the irrigation reservoirs in the dry zone are also used for drinking without appropriate purification. Moreover, recently, an epidemic of Chronic kidney disease of unknown etiology (CKDu) prevailing in North Central Province has increased the concern of cyanobacteria in these water bodies. Chronic kidney

disease (CKD), also known as chronic renal disease, is a progressive loss of renal function over a period of months or years. Many studies have been conducted over the last eight years with a view to elucidating the prevalence, nature and cause of CKDu in several parts of Sri Lanka. However, from the studies conducted so far, CKDu reported cannot be related to diabetes, hypertension, snakebite or any other known causes of traditional kidney diseases but likely triggered by an environmental factor.

Cyanobacteria, the ancient oxygen-evolving photoautotrophs are the dominant microbial inhabitants of rice fields. According to a study in India, following genera of *Anabaena*, *Cylindrospermopsis*, *Hapalosiphon*, *Lyngbya*, *Nostoc*, *Phormidium*, *Oscillatoria*, *Aulosira*, *Gloeotrichia*, *Fischerella*, *Aphanothece*, *Gloeothece*, and some unidentified cyanobacteria were present in paddy fields. As mentioned above most of these genera have the toxin generating ability. Therefore, there is a possibility that cyanotoxins is a cause for the CKDu in Sri Lanka.

Aims and Objectives

To (1) determine the cyanobacterial diversity in different geographical locations of Sri Lanka and their potential toxic generating ability.

Morphological and molecular data will be used and thereby a rapid DNA method will be developed to determine their potential toxin producing ability.

To (2) determine whether cyanotoxins are a risk factor for the CKDu prevalent in the North Central Province of Sri Lanka

Molecular and bio assay methods will be used for this purpose.

Results

A series of field expeditions were made to collect water and soil samples from different environments. Cyanobacteria were grown in culture media and microscopic observations were used to identify diversity of cyanobacteria isolated from different sites. Based on morphological features cyanobacteria were tentatively identified as *Microcystis aeruginosa*, *Chroococcidiopsis* spp., *Oscillatoriales* cyanobacterial spp., *Plectonema* spp., *Synechococcus* spp., *Synechocystis* spp., *Calothrix* spp., *Leptolyngbya* spp., *Limnothrix* spp., *Pseudanabaena* sp., *Microcoleus* sp., *Chlorogloeopsis* spp., *Merismopedia*

sp., *Cyanothece* sp., *Nostoc* sp., *Anabaena* sp., *Spirulina* sp., *Cylindrospermopsis* sp. and *Calothrix* sp. Genomic DNA was isolated and purified from environmental samples and cultured cyanobacterial isolates using Boom's method. A PCR procedure was developed for the selective retrieval of cyanobacterial rRNA gene fragments from a variety of natural and artificial settings and to determine the phylogenetic relationship and DNA partial sequencing was completed from the tentatively identified 93 cyanobacterial species. The sequences obtained from this study were deposited in the GenBank at the National Center for Biotechnology Information (NCBI) and some selected species are shown in Table 1.

The detection of toxic cyanobacteria and their toxins is fundamental for water management as such investigations of cyanotoxins present in Sri Lanka water bodies' needs extensive attention. We developed a rapid DNA-based method to identify toxin producing cyanobacteria from Sri Lankan reservoirs. Cyanobacteria isolated from Lake Gregory, Lake Beira and Kandy Lake showed the presence of potential microcystin producers. DNA-based detection methods may provide proper solution because of their potential specificity (targeting genes involved in toxin biosynthesis), sensitivity and speed.

The geographical distribution of CKDu appears to be biased towards the North Central Region (NCR) of the country and also part of North Western and part of Uva provinces. The populations at risk are scattered in the North Central Region with high prevalence observed at Medawachchiya, Padaviya, Dehiattakandiya, Girandurukotte, Medirigiriya, Kabithigollawa and recently Nikawewa. Targeting the CKDu issue disease information from 200 kidney patients of unknown etiology attending the Kidney Dialysis Clinic at Girandurukotte hospital were collected along with 98 blood and urine samples and 120 water samples from different water sources (well water, streams, paddy etc) of kidney patients of unknown etiology were also collected. Further 25 water samples from 3 tanks in the Anuradhapura District, Nuwara wewa, Tissa wewa and Kala wewa, were also collected for analysis. Genomic DNA was isolated and purified from environmental samples and cultured cyanobacteria using Boom's method. PCR conditions were optimized to identify the presence of cyanotoxin, cylindrospermopsin and *Cylindrospermopsis raciborskii*. PCR was done to identify cyanobacteria (unicellular and filamentous types) cylindrospermopsin toxin and *Cylindrospermopsis raciborskii*. For microcystin, from *Microcystis*, a positive amplification resulted.

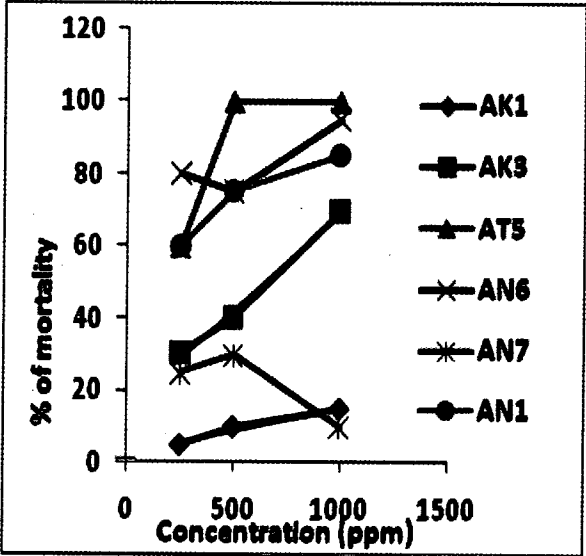


Figure 1. Percentage mortality of *A. salina* for different environmental filters

Table1. Isolated Cyanobacteria with GenBank Accession numbers

Sample Name	Accession Number	Organism
BL1	EF051239	<i>Microcystis aeruginosa</i> BL1*
BL1	EF051238	<i>Microcystis aeruginosa</i> BL1 <i>mcyE</i> gene
1R	EU276382	<i>Chroococcidiopsis</i> sp. 1R*
H1	EU276384	Oscillatoriales cyanobacterium H1
H2	EU276385	Oscillatoriales cyanobacterium H2
YRS 3	EU310419	<i>Plectonema</i> sp. YRS 3
N2b	GU368105	<i>Synechococcus</i> sp. N2b
N14	GU368106	<i>Synechococcus</i> sp. N14
N1a	GU368107	Chroococcales cyanobacterium N1a
N11N1b	GU368108	<i>Microcystis aeruginosa</i> N11*
N1b	GU368110	<i>Calothrix</i> sp. N1b
N2c	GU368111	<i>Leptolyngbya</i> sp. N2c
na1	GU368112	<i>Limnothrix</i> sp.na1
na3	GU368113	<i>Pseudanabaena</i> sp. na3
M3	GU594024	<i>Chroococcidiopsis</i> sp. M3
M1	GU594025	<i>Leptolyngbya</i> sp. M1
T2	GU594035	<i>Microcoleus</i> sp. T2
WWS1	GU594036	<i>Chorogloeopsis</i> sp. WWS1
Ku1	GU815987	<i>Merismopedia</i> sp. Ku 1
TW1	GU815989	<i>Cyanothece</i> sp. TW1
KW5	GU967428	<i>Leptolyngbya</i> sp. KW5
KW6	GU967429	<i>Synechococcus</i> sp. KW6

* Potential microcystin producers

Bioassay was performed for 12 samples using brine shrimp (*A. salina*) to test the lethality of water samples in three tanks. Both filtrate and filter was assayed and higher toxicity was recorded from filters of both environmental and cultured samples (Figure1). According to our findings in Anuradhapura water samples (Nuwara wewa, Tissa wewa and Kala wewa), has a vast distribution of cyanobacterial species with toxic generating ability and it might be a major risk factor for the CKDu in the dry zone.

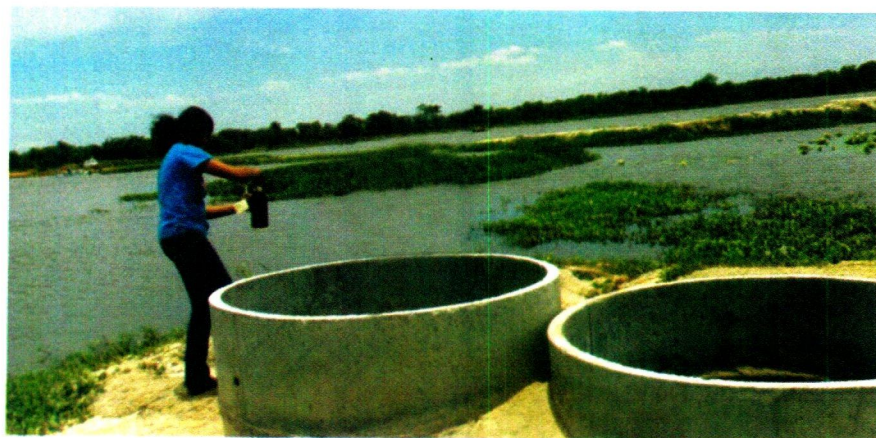
Relevance of results achieved to national / socio-economic development

Based on morphological features and molecular data immense diversity of cyanobacteria was identified from samples collected throughout the country. Screening of identified cyanobacterial species will be carried out with a view of their potential innovation in pharmaceuticals, new enzymes or new chemicals for biotechnology industry.

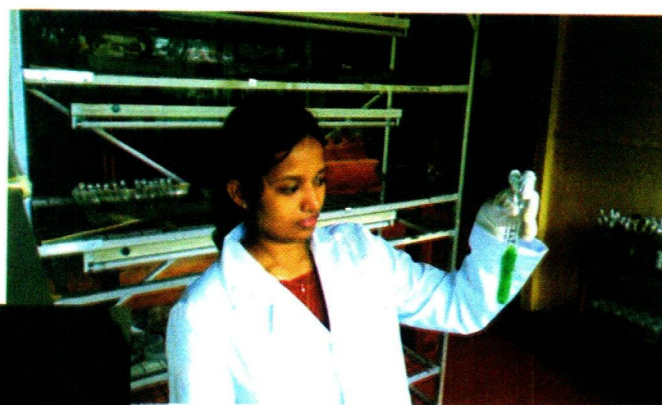
In the present study we have used PCR-based tests for determination of microcystin producing ability of cyanobacteria in selected locations.

Due to the high sensitivity of PCR, it is possible to detect toxic genotypes long before a toxic cyanobacterial bloom may occur. The technique used in this study was found to be highly sensitive for detecting the presence of microcystin-producing ability of cyanobacteria both from environmental samples and cultured isolates. As a developing country we have to find toxicity levels of water bodies and should maintain toxicity level minimally; otherwise more money would have be spent on purifying drinking water sources to overcome health problems.

More epidemiological studies are required to explore the relationship existing between human illnesses and cyanotoxins in water. As the actual cause for CKDu is still unknown, identification of the causative agent is an important national health concern. Further, if cyanotoxins are identified as the cause for CKDu, further monitoring, remediation and prophylaxis methods could be employed for water sources to prevent toxic cyanobacterial growth and also medical treatments could be initiated as a medical therapy and thereby rescue victims and further susceptible victims for the disease.



Field visit to Nelumwewa hot springs, Polonnaruwa



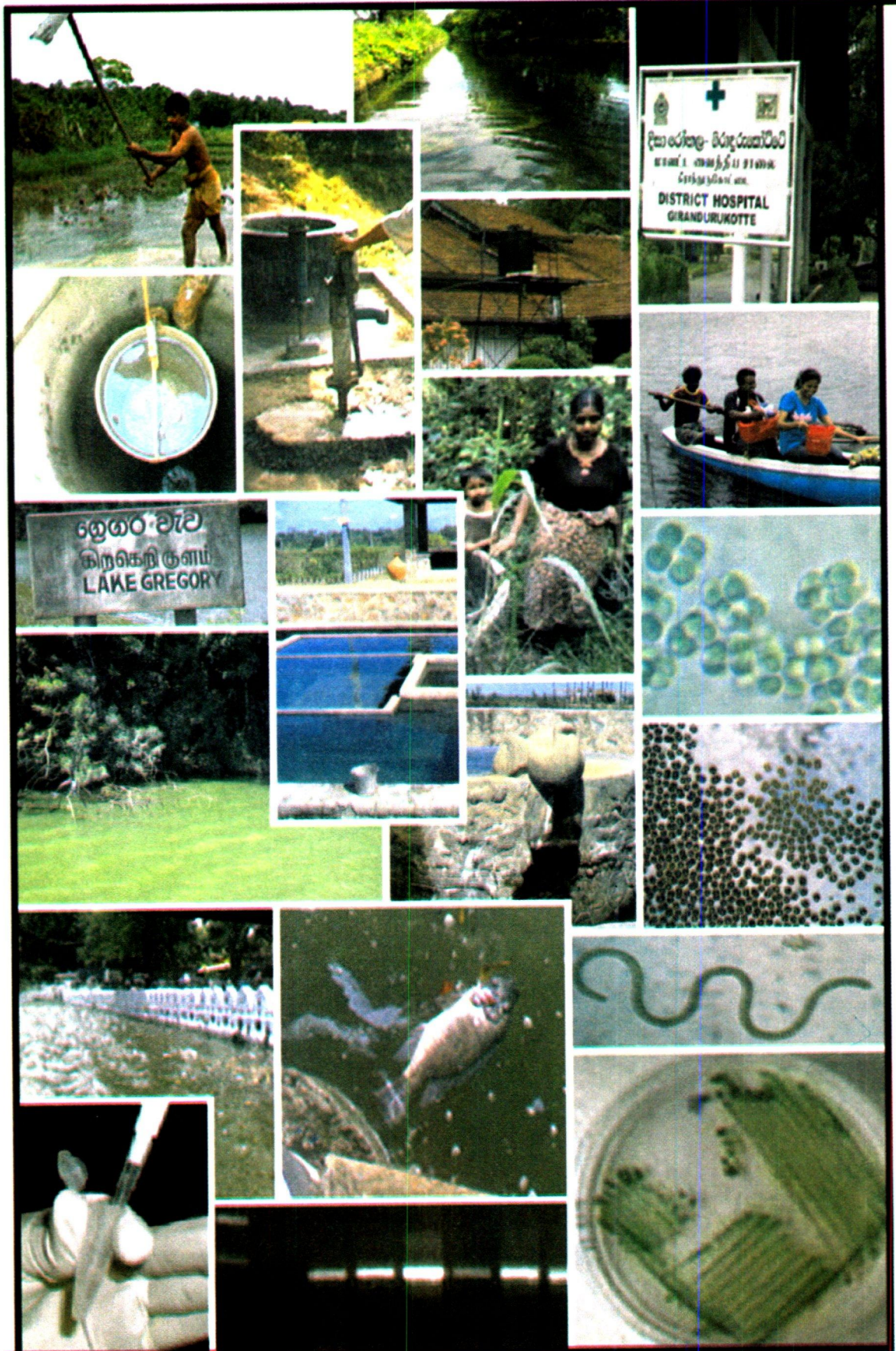
Laboratory Work



Laboratory Work



Cell Biology Research group



Field and laboratory work

References

1. Aturaliya, T.N.C., Abeysekara, D.T.D.J., Amarasinghe, P.H., Kumarasiri, P.V., & Bandara, P. (2006). Towards understanding of Chronic Kidney Disease of North Central Province. In *Proceedings of annual scientific sessions of Sri Lanka Medical Association* 2006.
2. Chandrajith, R., Nanayakkara, S., Itai, K., Aturaliya, T. N. C., Disanayake, C. B., Abeysekera, T., Harada, K., Watanabe, T. & Koizumi, A. (2010). Chronic kidney diseases of uncertain etiology (CKDu) in Sri Lanka: geographic distribution and environmental implications. *Environmental Geochemistry and Health*. DOI 10.1007/s10653-010-9339-1.
3. Falconer, I.R. Cyanobacterial Toxins of drinking Water Supplies: Cylindrospermopsins and Microcystins. 2005. Chapter 5 Cyanobacterial poisoning of livestock and people. CRC press, Boca Raton, FL.
4. Falconer, I.R., Beresford, A.M., Runnegar, M.T. (1983). Evidence of Liver Damage by toxin from a bloom of the Blue- Green Alga, *Microcystis aeruginosa*. *Medical Journal of Australia* 1:511-514.
5. Hawkins, P.R., Runnegar, M.T., Jackson, A.B. & Falconer, I.R. (1985). Severe hepatotoxicity caused by the tropical cyanobacterium (blue-green algae) *Cylindrospermopsis raciborskii* (Woloszynska) Seenaya and Subba Raju isolated from a domestic water supply reservoir. *Applied and Environmental Microbiology* 50: 1292-1295.

7.3.7 Research summary

WHY DO WE NEED RESEARCH ON TUBERCULOSIS?

B.A.C. de Silva, and D.N. Magana-Arachchi

Introduction

Doctors and scientists through out the world are conducting research on tuberculosis (TB). TB research studies are designed to answer important questions and to find out whether new approaches are safe and effective and it already has led to many advances, and researchers continue to search for more effective methods for dealing with tuberculosis.

Some people with TB do not get better with tuberculosis treatment because their disease is caused by a TB strain that is resistant to one or more of the standard tuberculosis medicines. This is known as drug-resistant TB. A patient may have drug-resistant TB, if their tuberculosis cannot be treated by one or more of the standard tuberculosis medicines. Some people may even have multidrug-resistant tuberculosis (MDR), a condition in which the tuberculosis bacteria become resistant to two or more of the most important medicines: isoniazid and rifampin. Those infected with drug-resistant tuberculosis face more complications and will have to stay on medication for a much longer period of time. MDR tuberculosis is an emerging problem of great importance to public health, with higher mortality rates than drug-sensitive TB. People with MDR -TB must be treated with several antibiotics every day for up to two years. The bacteria must respond to at least three of these other antibiotics. These medicines are not as good as the usual medicines for TB, and they may cause more side effects. Also, most people with MDR-TB must see a doctor who can closely observe their treatment to make sure it is working. Even with this treatment, between four and six out of 10 patients

with MDR-TB will die, which is the same rate seen with TB patients who are not treated. Therefore to control the rising numbers of MDR-TB and extensively resistant TB (XDR-TB) cases require methods for rapid detection and tracing sources of infection. That is an understanding of the epidemiology of tuberculosis (TB) is critical for effective control.

The *Mycobacterium* strain classification or sub typing is important epidemiologically for recognizing outbreaks of infection, detecting the cross transmission of nosocomial pathogens, determining the source of infection, recognizing the particularly virulent strains of organisms and in monitoring vaccination programs. DNA fingerprinting, of which restriction fragment length polymorphism (RFLP) typing, the most common method used has permitted novel investigations of the epidemiology and pathogenesis of tuberculosis. Spoligotyping, another method of DNA finger printing, is a polymerase chain reaction-based method for simultaneous detection and typing of *Mycobacterium tuberculosis* strains. The rapidity of this method in detection and typing could make it useful in the management of tuberculosis in a clinical setting.

TB has been a dreaded disease in Sri Lanka for centuries. Known as "Kshaya Rogaya" or "Kasa Rogum", these names aptly describe the disease as being associated with cough and wasting. TB, primarily affects young, between the ages 15 and 54, and the less affluent, who nevertheless, form the backbone of the economy of the country. The incidence of mortality was 8 per 100,000 in 2008 and estimated prevalence rate per 100,000 population for all forms of TB was 79.

Aims and Objectives,

- * To study mechanisms for person to person transmission of pulmonary TB among the general population and their effect on the epidemiology of TB. RFLP analysis and Spoligotyping on *M.tuberculosis* strains isolated from patients attending the Central Chest Clinic, Kandy, will be used for this purpose
- * To develop a simple, rapid and inexpensive assay based on PCR methodology for direct detection of MDR strains from patient's clinical samples
- * To develop an assay to differentiate tuberculosis and mycobacterium other than tuberculosis (MOTT) in patients using PCR methodology.

Results

To determine a detailed picture of TB epidemiology in Kandy, Sri Lanka, a total of 190 sputum specimens obtained from tuberculosis patients, who were positive for acid fast bacilli, were cultured. In addition, as a control population 25 sputum samples were collected from patients attending the same clinic, who were negative for acid fast bacilli. Of the 178 specimens (from the first visit patients) inoculated into TB specific media, 122 (68.5%) grew within eight weeks of incubation. The remaining did not grow or were contaminated. Only one of the 12 specimens from patients with recurrent tuberculosis grew during the eight week incubation period. Of the 25 specimens (from control population) four grew within five days of incubation indicating the presence of mycobacterium other than tuberculosis (MOTT).

In RFLP, the majority of the circulating *M. tuberculosis* strains in Kandy belong to a single family, but the degree of DNA polymorphism among strains was high. In total 71 distinct patterns were found with strains clustering into one main family and 10 distinct strains. Within the main family three isolates were grouped into one cluster, with closely related isolates while rest of the bacterial strains was grouped into one. Strains containing a single copy of IS 6110 were predominant among the study population (12) and except for three, the location of the bands in fingerprints were different. Among the strains tested there were 25 strains that lacked the IS 6110 element.

In spoligotyping, 110 *M. tuberculosis* isolates revealed a total of 24 families including the nine major families; *M. africanum*, *M. bovis*, East African-Indian (EAI) Beijing, Haarlem, Latin American and Mediterranean (LAM), Central and Middle Eastern Asian (CAS), a European family X, and a default family T and the most predominant group corresponded to Family33. Strains were distributed among all three principal genetic groups PGG1, PGG

2 and PGG3. Segregation of *M.tuberculosis* into 'ancestral' versus 'modern' lineages based on PGG indicates that isolates from Kandy have originated from both lineages. In spoligotyping high strain diversity was seen and except for two strains ST1 and ST 585 the rest were not defined in the latest spoligotype data bases SpolDB4/SITVIT.

Table 1. IS element copies (IS 6110) found in study groups

Number of IS 6110 copies	Number of Strains	% of strains
0	15a+10b=25	2.5
1	12	12.2
2	3	3.1
3	3	3.1
4	5	5.1
5	4	4.1
6	9	9.2
7	3	3.1
8	4	4.1
9	6	6.1
10	6	6.1
11	8	8.2
12	2	2.04
13	1	1.02
14	3	3.1
15	1	1.02
16	2	2.04
17	1	1.02

^a MTC / MTb *Mycobacterium tuberculosis*,

^b not successful (~ MOTT)

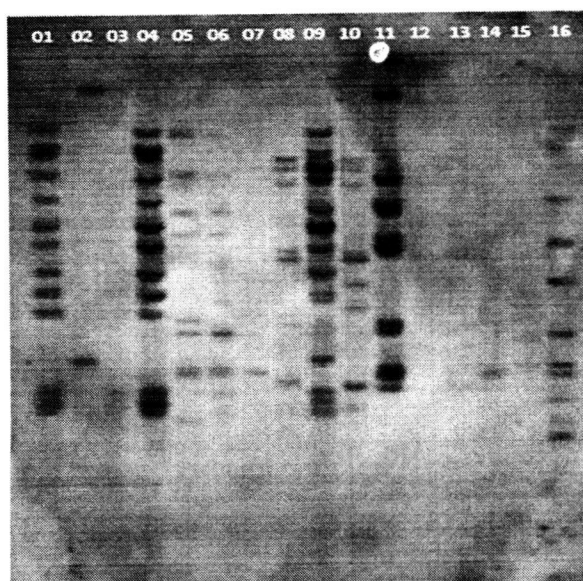


Figure 1. IS 6110 DNA fingerprinting of *M. tuberculosis* strains originating from study population

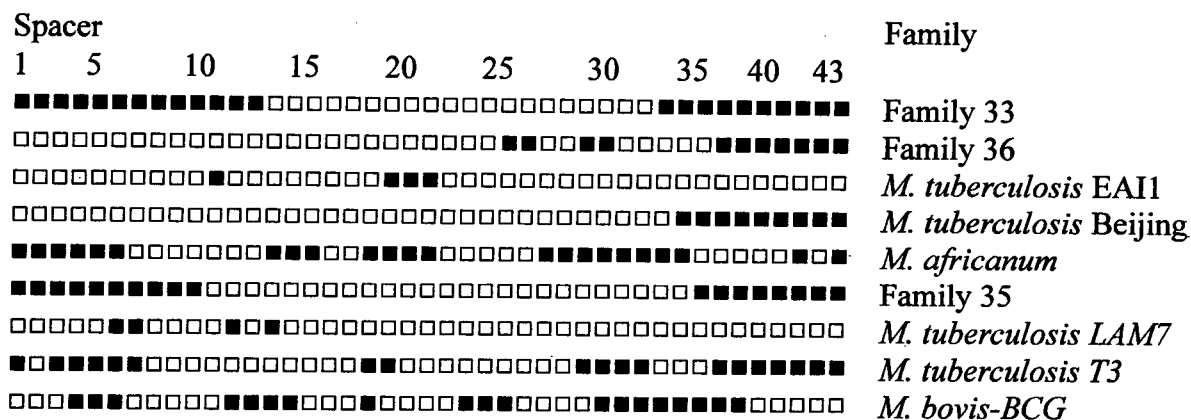


Figure 2. Spoligotyping patterns obtained from study population

1.4% of the *M. tuberculosis*/*M. tuberculosis* complex isolates from first visit patients showed isoniazid resistance and 23.3% were resistant to rifampin. 1.4% were multi-drug resistant. Sixteen (22.5 %) *M. tuberculosis*/*M. tuberculosis* complex isolates were found to be rifampin resistant while being sensitive to isoniazid. During this period Gene sequencing was completed for 54 strains of *M. tuberculosis* and nucleotide sequences obtained from Gene Sequencing for *inhA* ($n=3$), *katG* ($n=16$) & *rpoB* ($n=35$) genes were deposited in GenBank under accession numbers, GQ369430 -GQ369437; GQ 868653-GQ868655, GQ871909 -GQ 871920, HQ540563 -HQ540578 and HQ589040 to HQ589056. All the susceptible strains tested for DNA sequence possessed wild-type sequences whereas most of the resistant strains tested had mutations. One of the three MOTT isolates with rifampin resistance (M76), sent for sequencing was later found (by PCR) to be mixed- including an isolate of *M. tuberculosis* strain in addition to the MOTT strain from the same patient. The DNA sequencing of this isolate revealed a *M. tuberculosis* wild type pattern. Therefore, it was concluded that this particular tuberculosis patient was infected with two different strains, one MOTT, which was resistant to rifampin and the other *M. tuberculosis*, sensitive to rifampin. The concept of simultaneous infection with different strains of mycobacteria is not new and has been described previously. Isoniazid-dissociated rifampin resistance identified in the present study has rarely been reported before. High rate of rifampin resistance among the tuberculosis patients in Kandy emphasizes the need for a rapid and reliable method of diagnosing drug resistance in this country.

From the analysis of socio - demographic data, the majority were males (69.4%) with 30.6% females. However in control population this was different with both females and males occurring in equal ratio. According to the data, 90% of the population was in the age group of 16 and 60, and the less affluent, who nevertheless, form the backbone of the economy of the

country. There were no significant differences among two categories except for the two parameters contact history of TB and being out of the country (travel-abroad) by the patient.

Relevance of results achieved to national / socio-economic development

TB, primarily affects the young, between the ages 15 and 54. WHO estimated sputum smear positive pulmonary TB rate for Sri Lanka is 32 (3 year average), 2006, 2007, 2008. One of the most important challenges in the control of TB is a rapid diagnosis of cases and the optimization of anti tuberculous treatment, mainly to prevent the development of resistance and the dissemination of resistant strains. It has been noted that the DNA polymorphism could be made use of to identify transmission rates of drug resistance and drug sensitive strains. RFLP typing can be carried out on primary isolates to determine drug resistance. By comparison of these isolates with the existing RFLP patterns of the drug resistance isolates the time taken for determining drug resistance may be much shorter compared to the conventional antibiotic sensitivity testing which takes more than four weeks.

Spoligotyping, a new method for simultaneous detection and typing of *M. tuberculosis* complex bacteria is based on PCR technique and avoids the timing problems associated with the slow growth of the bacteria. Being a rapid method spoligotyping can be used in clinical setting for diagnostic purposes as well as for epidemiologic studies for TB transmission.

This is the first study in Sri Lanka in which both the RFLP pattern of *M. tuberculosis* strains and the spoligotyping in a population has been examined. In most of the countries the RFLP and spoligotyping patterns are recorded from each tuberculosis patient and data are deposited for future reference in

treatment. In this study we have demonstrated the feasibility of establishing molecular typing methods in Sri Lanka especially in spoligotyping without using any commercial kits. At present, TB patients in Sri Lanka get free treatment. If chronic cases could be prevented and/or cured this could lead to considerable savings in the national economy. It is now widely appreciated that better health has an important role in reducing poverty and promoting economic growth.

Dissemination and application of research output

If necessary, PCR and spoligotyping on TB can be established at the Institute of Fundamental Studies, Kandy and services can be provided to any interested Institute either in Government or private sector. Therefore establishment of molecular typing methods in Sri Lanka will not only be useful to study strain variations in epidemiological analysis but may be used

beneficially in treatment of patients as well as identifying patients carrying drug resistance strains and on reactivation of the disease.

References

1. Kamerbeek J, Schouls L, Kolk A, et al., Simultaneous detection and strain differentiation of *M. tuberculosis* for diagnosis and epidemiology. *Journal of Clinical Microbiology*. 1997; 35;907-914.
2. Kubica GP, Dye WE, Cohn ML and Middlebrook G. Sputum digestion and decontamination with N-acetyl L-cysteine as a sputum digestant for the isolation of mycobacteria. *American Review of Respiratory Disease* 1963; 89; 284-86.
3. van Soolingen D, de Haas PE, Hermans PW, Soll DR and van Embden JD, Occurrence and stability of insertion sequences in *Mycobacterium tuberculosis* tuberculosis. 1991;29;2578-2586. *Journal of Clinical Microbiology*.

7.4 CHEMICAL AND ENVIRONMENTAL SYSTEMS MODELING PROJECT

Project leader: Dr. M Vithanage, Research Fellow

The research group of Chemical and Environmental Systems Modeling began in the latter half of 2009. Groundwater serves as a good source but it may be unfit for consumption because of natural, anthropogenic pollution, effect of climate change and sea level rise. Studies aimed at understanding chemical processes in solid solution interfaces, to assess and characterize groundwater pollution were carried out, and these systems were modeled in order to find solutions for human benefit.

7.4.1 Natural dissolution mechanisms of serpentinite; Possible toxic element leaching to the environment

Ultramafic rocks such as serpentinite in Sri Lanka is known for high concentrations of trace metals, Cr, Ni, Co and Fe that may cause groundwater pollution leading to ecological and health problems for the local population. The objective of this research was to understand the mechanisms of natural dissolution of these heavy metal species from serpentinite rock and soil, and to assess change in the metal dissolution behavior based on environmental factors such as pH, oxides etc. Some of the local wells surrounding serpentinite deposits in Sri Lanka were found to be rich in Ni and Mn. Similarly, serpentine soil showed high release of Ni and Mn in the bioavailable and exchangeable fraction indicating risk of contaminating groundwater and absorption into plants.

7.4.2 Adsorption of arsenic on various materials in the presence of competing anions

This research component studied the effect of reaction time, loading and competing ions on arsenic retention on Natural Red Earth (NRE) and laboratory synthesized gibbsite nano particles.

Arsenic in groundwater is a worldwide problem. Materials can be developed for use in water filters for the removal of toxic metals in drinking water. Both nano-gibbsite and NRE were observed to be efficient in arsenic removal.

Competitive adsorption isotherm experiments showed a higher effect of PO_4^{3-} on the reduction of adsorption of both arsenic species than that with SO_4^{2-} and NO_3^- with NRE. FT-IR spectra indicated an inner sphere bonding of Fe-O sites with SO_4^{2-} and PO_4^{3-} groups while an outer-sphere weak complexation was observed with NO_3^- . Therefore, NRE and gibbsite nano particles could be potentially effective in removing arsenic in potable water.

7.4.3 Hydrogeochemical classification of groundwater in the Hambantota District, Sri Lanka

Hydrogeochemical characteristics of groundwater in the Hambantota district in Sri Lanka have been mapped to identify the groundwater types and water quality in the region. Groundwater samples were collected from forty three (43) tube wells at various selected locations in the study area. The physico-chemical parameters such as pH, EC, TDS, temperature, major cations and major anions were analyzed in order to understand the basic hydrogeochemistry of the water. The groundwater at many locations in the study area exceeded the WHO drinking water standards and therefore is not suitable for drinking purposes. The chemical composition of the groundwater is characterized by high EC, TDS, chloride, fluoride and this could be due to various reasons such as saltwater intrusion, weathering of rocks with high Ca, Mg etc. Widely distributed aquifer type in the study area is the Na/K – Cl type. Maps for each and every element analyzed were compared with the available historical data.

7.4.4 Adsorption of fluoride on natural materials

Hydrogeochemistry of groundwater in the dry zone of Sri Lanka indicated high concentrations of fluoride in tube wells. Fluoride in dry zone groundwater is attributed to weathering of granites, gneisses and fluoride bearing minerals. Dental fluorosis is the most common sign of excessive intake of fluoride rich drinking water. Presence of fluoride in water does not impart any colour, odor or taste. Therefore it acts as an invisible poison such as arsenic in groundwater. This research was carried out to investigate characteristics of different natural materials suitable for cost effective removal of fluoride. Commonly available natural materials like impure kaolinite (kirimeti), laterite, brick clay etc were used and the best material for fluoride removal was found to be laterite. Modeling studies indicated the existence of inner sphere chemisorptive bonding mechanism of fluoride on laterite surface and higher adsorption was observed in natural environmental pH levels (4-6).

7.4.5 Use of waste materials for heavy metal removal in landfill leachate

Two natural biosorbents to remove heavy metals from landfill leachate which contains high concentrates of

toxic metals and contaminates water sources were compared. Agricultural by products were found to be good biosorbents for the removal of heavy metals from aqueous solutions. Coconut husk and saw dust were tested for metal removal from leachate. The leachate tested from the Gampola landfill had high levels of Pb and Cd. Coconut husk performed better than saw dust in removal of Pb and Cd. A filter using both coconut husk and saw dust was established at the field at Gampola landfill and these materials are effectively adsorbing both Pb and Cd from the leachate.

The above projects resulted in the award of an M. Phil. Degree to a postgraduate student. Three other Research Assistants are registered for M. Phil. Degrees. Three university students and three other part time students also underwent training.

Collaborations:

SATREPS (Science and Technology Research Partnership for Sustainable Development): UoP, Saitama University, UoR – JICA – JST grant for 5 years on 'Site-Specific Pollution Control and Remediation Techniques for Waste Dumping Sites in Sri Lanka'.

Saitama University, Japan: Prof. Ken Kawamoto – small grant for research work on Water repellency behavior of soils

University of Copenhagen, Denmark: Prof. Peter Engesgaard and Prof. Karsten H. Jensen – M.Sc. research student from the University of Copenhagen works on 'The effect of sea level rise on coastal groundwater in Sri Lanka'. Dr. Meththika Vithanage is serving the student's advisory committee.

Shimane University, Japan: A research collaboration on 'Adsorptive removal of cadmium by Natural Red Earth: Equilibrium and kinetic studies' with a Ph.D. student K. Mahatantila.

University of Peradeniya: Dr. R. Weerasooriya, Dr. Athula Bandara, Dr. M.I.M. Mowjood, Dr. Shameen Jinadasa and Prof. B.F.A. Basnayake

Sabaragamuwa University of Sri Lanka: Dr. A.L.T. Hewawasam
National Water Supply and Drainage Board

Awards

A research paper that we contributed and presented by the Post Graduate Institute of Agriculture group was awarded as the best poster at the Leaching from

lysimeter simulation of rice straw landfill bioreactor and evaluation of fertilizer quality of resulting compost. 22nd Annual congress of the Post Graduate Institute of Agriculture, 2010.

A research paper that we contributed and presented by the Saitama University group was awarded as the best presenter at the 12th International Summer Symposium of the Japanese Society for Civil Engineers on September, 2010.

The project leader, Dr. Meththika Vithanage was selected to serve as a member in the International Participation Committee of the American Geophysical Union for 2 years from 2010.

Dr. Meththika Vithanage was awarded as the Best Graduate Scientist on Natural Hazards, 2009 by the Natural Hazards Focus Group, American Geophysical Union in 15th December, 2009 at San Francisco, USA

Human Resource Development

Research Assistants registered for post graduate degrees

Mr. I.P.L. Jayarathna – Ph.D. Student (Post Graduate Institute of Science – PGIS)

Ms. R.M.A.U. Rajapaksha – M.Phil. Student (PGIS)

Mr. Hasintha Wijesekera – M.Phil. registration pending at PGIS

Part time research students

Ms. Kirstine Wodschow – M.Sc. thesis student (University of Copenhagen, Denmark)

Ms. B.G.N. Sewwandi – M.Phil. Student (Post Graduate Institute of Agriculture – PGIA)

Volunteer research assistants

Mr. D.G.L.M. Jayarathna

Trainees

Mr. Janaka Kumara Hettiarachchi – Undergraduate student (Sabaragamuwa University of Sri Lanka, 2010)

Ms. S. Randiligama – Undergraduate student (University of Peradeniya, 2010)

Ms. R.M.A.G. Ramanayake – Undergraduate student (Sabaragamuwa University of Sri Lanka, 2009)

7.4.6 Research summary

SOME GEOCHEMICAL FORMS OF TOXIC ELEMENTS IN NATURALLY AND ANTHROPOGENICALLY CONTAMINATED SOILS

Anushka Upamali Rajapaksha¹, H.R. Wijesekara¹, I.P.L. Jayarathna¹,
D.G.L.M. Jayarathna¹, B.G.N. Sewwandi² and Meththika Vithanage¹

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²*Post Graduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka*

Introduction

Even minute concentrations of toxic elements such as arsenic, lead, cadmium, nickel, chromium etc can cause serious damages to biological systems. Toxic metal sources can either be natural or anthropogenic. Rocks may consist of toxic metals according to their origin while soils beneath waste dumping sites can contain toxic metals leaching from the wastes such as electronics, batteries, paints and other chemicals etc.

Toxic metals can be released to the environment by weathering and dissolution from both natural and man made sources. However, leaching of these metals depend on their bonded forms of speciation. Metal bounded forms have been classified into different fractions, however, bioavailable and exchangeable fractions are the most important considering the environment. Toxic metals in the bioavailable fraction will be taken by plants when metals in the exchangeable fraction are dissolved in water. Therefore, it is of importance to study the toxic metals in bioavailable, exchangeable fractions and their leachability from soils that are rich in toxic metals. In this paper, we discuss results from two different soils, serpentine soil from Ussangoda and soils from two waste dumping sites, Gampola and Gohagoda, Kandy.

Materials and Methodology

The serpentinite soil used for the study was obtained from Ussangoda, Ambalantota, Southern Sri Lanka. Ussangoda is striking in its contrast with the rest of its surrounding. A plateau of hard red colour soil with almost no vegetation has led to many beliefs (Figure 1). Most popular beliefs are that this area may have been stroked by a meteorite or the monkey god Hanuman torched the earth when he came to help Rama to search for Seeta in the King Ravana of India's epic Ramayanaya.

Serpentinite soil tends to be rich in magnesium, chromium and nickel - elements that are probably toxic to many plants (Rajakaruna and Bohm 2002). Serpentine soil, a direct weathering product of serpentinite rock underneath, which is altered after magmatic intrusion, was obtained for the experiments.

Other soil samples were obtained from different places of the Gampola and Gohagoda waste dumping sites (Figure 2 & 3). Total soil samples collected were 26. These open dump sites are very close to the river Mahaweli, which is the main drinking source of water for Kandy District.

Some geochemical forms of metals were determined by the extraction procedures as in Figure 4.

(i) Bioavailable:

The soil was extracted with 10 ml of 0.01 M CaCl₂. The solid solution was stirred, centrifuged and filtered. The supernatant was taken for analysis.

(ii) Exchangeable:

The sediment was extracted at room temperature with 20 mL of magnesium chloride solution (1 M MgCl₂, pH 7.0) with continuous agitation.

At the same time water samples and leachate samples were analyzed for toxic metals to understand the risk of pollution in the vicinity.

Results and Discussion

Serpentine soil

In the exchangeable fraction, the amount of Ni was higher than that of Mn. Chromium was observed to be low in the exchangeable fraction compared to both Ni and Mn. The order of release into exchangeable fraction can be described as Mg > Ni > Mn > Fe > Cr. Metal concentrations extractable into the bioavailable fraction were rather high for serpentine soil. However, compared to the exchangeable fraction, concentrations in the bioavailable fraction seemed low. On average Ni was shown to have high concentrations and a similar pattern was observed for other metals in this fraction.

Groundwater in the vicinity of a serpentinite body was investigated and it was revealed that the concentration of Ni is few times higher than the WHO guideline value (0.02 ppm). The average Ni concentration in groundwater around Ussangoda serpentinite deposit is 0.18 ppm.

Gampola and Gohagoda landfill soils

Interestingly data from the Gampola landfill showed higher concentrations of total metals (Figure 5) compared to soils from Gohagoda although the Gohagoda landfill is large and older compared to Gampola. Higher concentrations were reported for zinc in average for both Gampola and Gohagoda landfill leachate contaminate soil compared to normal soils (Figure 5) while the highest concentration was reported for copper (2.5 g/kg) at one of the Gampola samples.

However, average zinc concentrations in the Gampola leachate contaminated soils (700 mg/kg) were 3.5 times higher (Table 1) than that of Gohagoda (200 mg/kg). Chromium and lead were also present in high values at Gampola samples compared to Gohagoda leachate contaminated soils (Table 1). Manganese concentrations alone showed higher concentrations in the Gohagoda landfill. High lead and manganese concentrations may be from batteries while zinc, copper and chromium may be from electronics, tins and other metal from dissolutions.

Table 1. Average metal concentrations of landfill leachate contaminated soils

Sample locaton	Cu	Pb	Zn	Cd	Ni	Mn	Cr
Gampola	596	373	700	6	67	90	136
Gohagoda	105	76	194	2	60	988	47

Note: Data in mg/kg

Results showed that the bioavailable and exchangeable metal ion concentrations were high compared to the standards given in Pilc et al (1994). Lead was the most bioavailable metal while zinc and copper were the rest (Figure 6). This pattern was similar for exchangeable metals although the concentrations were much higher. Since a part of the exchangeable fraction comes under bioavailable the exchangeable fraction should show higher values.

Leachate samples that were analyzed from the Gampola landfill showed high values for copper, nickel and lead in average 0.5, 0.2 and 0.1 mg/L respectively.

Remarks

According to the results obtained from serpentine soil, it was observed that nickel may be released fast into the environment and can be a threat to the local groundwater. Landfill leachate contaminated soils showed that it has a natural attenuation capability on toxic metal pollution. The soils may bind the metals on their surfaces and only the weakly bonded metals are

releasing into the environment from exchangeable and bioavailable fractions. However, high concentrations of zinc, copper, lead and manganese can be released to the environment from both Gampola and Gohagoda dump sites. This may again be a threat to the water quality of the Mahaweli river.



Fig 1. Ussangoda serpentine soil



Fig 2. Gampola waste dump. Mahaweli river is just adjacent to the dump site.



Fig 3. Gohagoda open dumping site

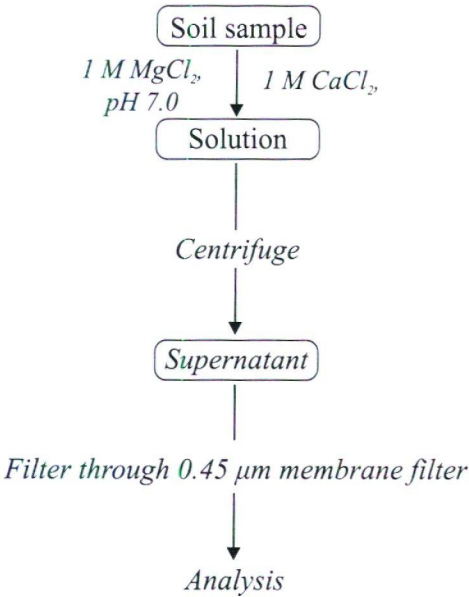


Fig 4. Methodology of leaching experiments

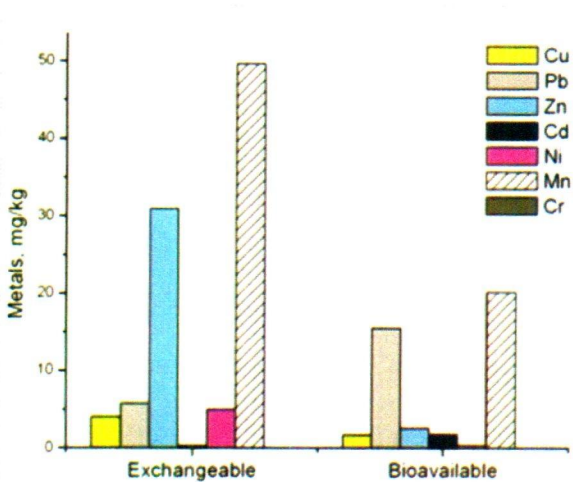


Fig 5. Metals available in total digested soils from Gampola and Gohagoda landfill (average is shown)

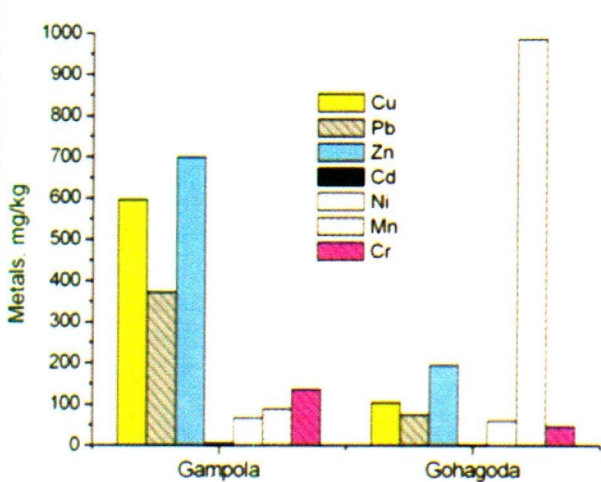


Fig 6. Exchangeable and bioavailable metals in studied landfill leachate contaminated soils

7.5 CONDENSED MATTER PHYSICS AND SOLID STATE CHEMISTRY PROJECT

Project leaders: Prof. G.K.R. Senadeera and Prof. M.A.K.L. Dissanayake

The Condensed Matter Physics project was initiated in 1987 and the work upto 2008 was largely focused on liquid state and solid state dye sensitized solar cells. At the same time investigations have been extended to include polymeric electrolytes based dye sensitized solar cells using inorganic and organic dyes with the initiation of the Solid State Chemistry Project (commenced in 1999), which deals with the investigations on the determination of fundamental physico-chemical aspects that are centered to electrically conducting polymers and conventional semiconductors, which have been the object of increasing academic and technological interest during the last 10-15 years.

Objective of the Project:

The chemical aspects of these projects specifically targeted at novel ways of synthesising, new organic, inorganic, layered or porous semiconducting solids, and hybrid organic-inorganic compounds which were synthesized either in the bulk or as thin films or nano particles. The structural and surface properties will be addressed both from *in situ* and *ex situ* experimental methods in the physical aspects of the project. A particular emphasis is paid to electrical (metallic or semiconductors, ionic and mixed polymeric conductors) properties associated with the microstructures of these solids. The Standard characterization methods such as cyclic voltametry (CV), SEM, TEM, XPS, FTIR, AC impedance and photocurrent spectroscopy are being used to characterize the materials involved in these investigations.

Relevance to national development

Since Sri Lanka is a tropical country with long hours of sunshine, it has a great potential for harnessing solar energy and therefore, from a national perspective, this study is expected to strengthen the already existing knowledge base in solid-state physics, materials sciences and also in solar cell technology. It also increases the cadre of scientists working on novel materials and device in Sri Lanka. This we believe is essential for the long term scientific and technological development of the country. With such a knowledge base and a trained carder of scientists, the possibility exists for Sri Lanka to invest on a new and emerging technology for the fabrication of environmentally friendly mini and micro-power sources with high energy solid state devices.

Significant achievements (2009-2010)

7.5.1 Efficient passivation of SnO₂ nano crystallites by Indoline D-149 via dual chelation

In order to explore the possibility of using double or multiple chelating mechanism on the reduction of recombination rate, and efficiency enhancement in SnO₂ based dye solar cells, we have reported for the first time, efficiency exceeding 3% of the cells containing Indoline D-149 dye with unmodified SnO₂ nano-crystallites. As evident from the FTIR measurements, surface passivation of recombination centers of SnO₂ crystallites due to the dual mode of attachment of dye molecules to the surface of SnO₂ via both COOH and S-O direct bond might be the possible reason for this enhancement in these SnO₂ based cells.

7.5.2 Use of Surface Plasmon Resonance of gold nanoparticles for efficiency enhancement of dye sensitized solar cells with TiO₂

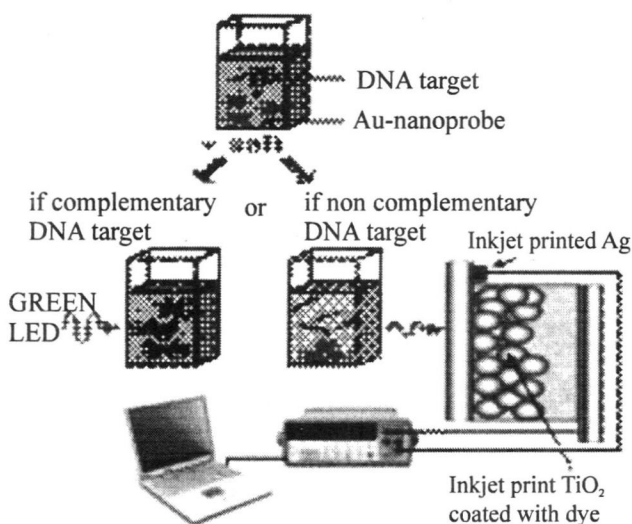
In this project, we showed that a significant enhancement in the overall efficiency of dye sensitized photoelectrochemical solar cells (DSSCs) based on TiO₂ can be achieved by incorporating gold nanoparticles into TiO₂ film. Polarization of gold nanoparticles and oscillations of electrons in the gold nanoparticle surface, positively influence the enhancement of photoresponse of these DSSCs as a consequence of the Surface Plasmon Resonance (SPR) effect, due to the creation of a local electromagnetic field.

Quasi Solid State Nano composite polymer electrolytes based on PVdF-PEO blend and their applications in dye sensitized solar cells (DSSCs). (This is a collaborative project started in 2009 with Prof. M.A.K.L. Dissanayake, Department of Physics, University of Peradeniya (Presently visiting Research Professor at IFS).

In order to obtain the best, solidified polymeric electrolyte to be used in DSSC applications, the effect of solidification, crystallinity, redox couple concentration, choice of cations and additives in the polymer electrolytes were investigated with the blend of poly(vinylidene-fluoride) (PVdF) and polyethelne oxide (PEO). The best electrolyte suitable for DSSCs with maximum solidification, showed high ionic conductivity in the order of $\sim 10^{-2}$

S cm^{-1} at 343 K. DSSCs fabricated using this electrolyte and TiO_2 electrodes sensitized with Ruthenium polypyridyl (N719) dye, delivered $\sim 13 \text{ mA cm}^{-2}$ photo current density with an open circuit voltage of $\sim 666 \text{ mV}$, yielding efficiencies $\sim 5\%$ which can be used in some practical applications..

7.5.3 Inkjet printed and “doctor blade” TiO_2 photodetectors for DNA biosensors



Schematic representation of DNA detection of the developed biosensor.

For the first time, we have developed a low cost, user-friendly biosensor comprising a gold nanoparticle based assay and a dye sensitized nanocrystalline TiO_2 , photodetector (a DSSC) especially suitable for developing countries. We presented also a new approach for the fabrication of dye sensitized TiO_2 photodetectors by an inkjet printing technique, a no mask and no vacuum patterning method, which is an ideal method for cost efficient mass production. For the assay, a specific DNA sequence from *Mycobacterium tuberculosis* was used.

Human Resource Development

1. A significant research base and a knowledge base have been developed on low cost, dye sensitized solar cells in order to initiate research and development and commercialization of them. The possibilities now exist for a state or private sector entrepreneurs to initiate Research and Development and commercialization work on some of these findings.

2. During 2009-2010 period, we have trained four M.Phil level research students, one PhD level student, five undergraduates and two pre-University students through out these projects.

7.5.4 Research summary

INVESTIGATIONS ON THE EFFICIENCY ENHANCEMENT OF DYE SENSITIZED SOLAR CELLS (DSSCs) AND THEIR APPLICATIONS.

Y.P.Y.P. Ariyasinghe, T.R.C.K. Wijayarathna, C.A. Thotawatthage and G.K.R. Senadeera,

Introduction

As the global energy demand is likely to double within the next 50 years and frightening climatic changes due to the greenhouse effect caused by fossil fuel combustion are anticipated, there is an urgent need to develop renewable energy sources to cover a substantial deficit left by fossil fuels. Among the sources of renewable energy, solar energy is considered the most promising. The development of new types of solar cells is promoted by increasing public concerns that the earth's oil reserves could run out during this century. Work at the IFS under this project deals with fundamental research towards solutions to the energy shortage. Photovoltaics, particularly, the dye-sensitized solar cells (DSSCs) (see Fig. 1) are taken as the system which offers

enormous potential as an alternative renewable energy provider.

The idea was first conceived in the late 1970's and the system has developed enormously after the publication in *Nature* by a Swiss Professor, Michael Gratzel. However, all these devices generally consist of expensive sensitizers such as ruthenium (II) polypyridyl complexes and electrolytes with volatile solvents. These factors, especially the fact that the liquid electrolyte causes significant technological problems associated with device sealing and stability, affecting in commercialization of these DSSCs. Therefore, there is considerable interest in both the development of a solid state electrolyte for these devices and replacement of expensive dyes with inexpensive and readily available materials.

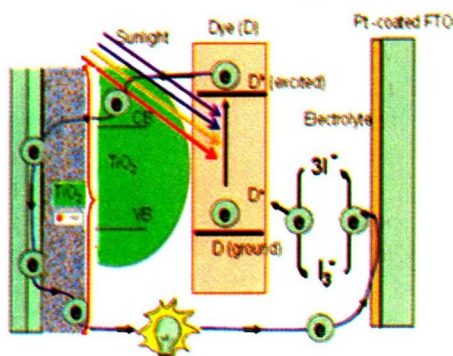


Fig.1 Schematic diagram of a DSSC.

On the other hand, in the context of the efficiency enhancement of these DSSCs, another important factor that needs to be considered is the semiconducting surface used to adsorb the dye molecules. Even though, TiO_2 has been used in these cells, numerous studies have been carried out by researchers including our group on the replacement of TiO_2 with other semiconductors like SnO_2 and structurally modified semiconducting surfaces.

Aims and Objectives

In order to fabricate low cost, and more efficient DSSCs, we have focused our investigations on the preparation and characterization of thin films of semiconductor nano-structures, identification of new semiconducting materials, solidification of liquid electrolyte with polymeric materials, replacement of expensive dyes either with natural pigments or electronically conducting polymers etc., As a practical application of our work, investigations have been carried out in the usage of DSSCs in low cost, simple and portable bio- sensing applications in connection with DNA identification.

Results (2009)

(a) Efficient passivation of SnO_2 nano crystallites by Indoline D-149 via dual chelation

In our previous studies we found that remarkable enhancement of the efficiencies of DSSCs, especially those based on SnO_2 can be achieved by covering SnO_2 crystallites with nano size insulating materials like Al_2O_3 or MgO . Therefore, investigations have been extended to check whether double or multiple chelating mechanism effect on the reduction of recombination rate, and efficiency enhancement in DSSCs based on the SnO_2 crystallites. We believe that, our findings will eventually support the synthesis of new dyes with double or multiple chelating moieties which can absorb many photons from the sunlight than by the dyes with single chelating ability.

Therefore, for the first time, in SnO_2 based dye solar cells, we have reported, efficiency exceeding 3% of the cells consisting with Indoline D-149 dye with unmodified SnO_2 nano-crystallites and found that that, on the basis of the FTIR measurements, surface passivation of recombination centers of SnO_2 crystallites due to the dual mode of attachment of dye molecules to the surface of SnO_2 via both COOH and S-O direct bond might be the possible reason for this enhancement in the SnO_2 based solar cells.

(b) Use of Surface Plasmon Resonance of gold nanoparticles in the efficiency enhancement of dye sensitized solar cells with TiO_2

In this context, we have shown that a significant enhancement in the overall efficiencies of dye sensitized photoelectrochemical solar cells (DSSCs) based on TiO_2 can be achieved by incorporating gold nanoparticles into TiO_2 film. Polarization of gold nanoparticles and oscillations of electrons of the gold nanoparticle surface, positively influence the enhancement of photoresponse of these DSSCs as a consequence of the Surface Plasmon Resonance (SPR) effect, due to the creation of a local electromagnetic field.

References

1. Regan B. O' and Grätzel, (1991). Dye sensitized solar cells, *Nature*, 353: 737-741.
2. Highly stable dye-sensitized solid-state solar cell with the semiconductor $4\text{CuBr} \cdot 3\text{S}(\text{C}_4\text{H}_9)_2$ as the hole collector, Tennakone, K., De Silva, D.B.R.A., Kottegoda, I.R.M., *Appl. Phys. Lett.*, 77:2367-2369.

7.5.5 Research summary

STUDIES ON POLYMERIC SOLID ELECTROLYTES AIMING TO REPLACE LIQUID ELECTROLYTES IN DYE SENSITIZED SOLAR CELLS, ELECTROCHROMICS AND LI BATTERIES.

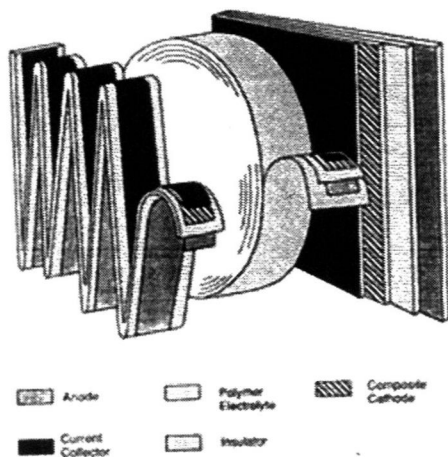
W.S.S. Gunathilake, C.A. Thotawatthage, T.R.C.K. Wijayarathna,
G.K.R. Senadeera and M.A.K.L. Dissanayake

Introduction

In the mid 1970's researchers had found that, a non conducting polymer, poly(ethylene oxide) (PEO) became ionically conducting when a lithium salt was incorporated into the polymer matrix. This class of materials is called solid polymer electrolytes. To date, PEO has been the most widely studied polymer host because, it contains only unsaturated C-O, C-C and H-H bonds. Moreover, it is chemically and electrochemically stable.

Even though the melting point of the crystalline phase of this material is high and the material shows low ionic conductivity at room temperature, there are many advantages of using these polymer

electrolytes in solid state ionic devices. These are, the ease of fabrication into thin films with large surface area, ability to accommodate a wide range of doping compositions of ionic salts, provide good electrode-electrolyte contacts, moderately



high ionic conductivity and the flexible nature of the polymer which can accommodate volume changes in many applications such as in dye solar cells and batteries. Other practical applications that are under consideration include fuel cells, electrochromic display devices and modified electrode/sensors. Since the potential of these materials have been realized for commercial application, other polymers such as poly(acrylonitrile) (PAN), poly(vinylidene fluoride) (PVdF), Poly(methyl methacrylate) (PMMA),

poly(vinyl chloride) (PVC) have also been proposed as hosts in electrolyte systems. Recently natural biodegradable polymers such as Rubber and Chitosan had also been studied. Among these, PVdF based polymer electrolytes are known to be chemically, electrochemically and thermally stable and have been widely used in gel electrolytes for lithium batteries. It is also well known that if a solvent is incorporated into the PVdF structure it is almost impossible to remove it completely. Therefore, by considering these facts, systems with mixtures of polymer matrixes will be more useful in many electrochemical applications.

Aims and Objectives

The overall aim of this work is the synthesis, characterization and identification of polymer electrolytes with desired properties, which can be used as electrolytes in practical applications such as dye sensitized solar cells (DSSCs), electrochromic displays (ELCDs) and Li batteries. In this context, investigations have been carried out to prepare soft and flexible free standing electrolyte films based on various polymeric materials (Fig.2) such as PEO, PAN, PVdF, PMMA, Natural Rubber (NR), Chitosan and Starch etc., to be used in above applications.

Results

In order to obtain the best, solidified polymeric electrolyte to be used in DSSC applications, the effect of solidification, crystallinity, redox couple concentration, choice of cations and additives in the polymer electrolytes were investigated with the blend of poly(vinylidene-fluoride) (PVdF) and polyethelne oxide (PEO). The best electrolyte suitable for DSSCs with maximum solidification showed high ionic conductivity in the order of $\sim 10^{-2} \text{ S cm}^{-1}$ at 343 K. DSSCs fabricated using TiO_2 electrodes sensitized with Ruthenium polypyridyl (N719) dye delivered $\sim 13 \text{ mA cm}^{-2}$ photo current density with an open circuit voltage of $\sim 666 \text{ mV}$, yielding efficiencies $\sim 5\%$.

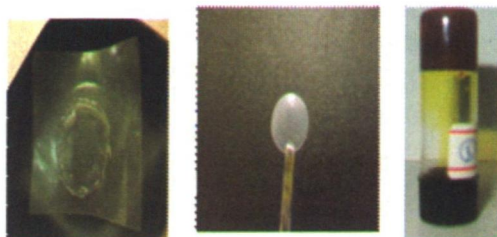


Fig.2. Quasi-solid-Polymeric electrolytes prepared for DSSCs and ELCDs.

References

1. Regan B. O' and Graetzel, (1991). A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO₂ films., Nature, 353: 737-740.
2. P.A.R.D. Jayatilaka, M.A.K.L. Dissanayake, I. Albinsson, B.-E. Mellander, (2003), Dielectric relaxation, ionic conductivity and thermal studies of the gel polymer electrolyte system PAN/EC/PC/LiTFSI, Solid State Ionics 156: 179-195.
3. Tennakone, K.; Senadeera, G.K.R.; Year 1999 Perera, V.P.S.; Kottegoda, I.R.M.; De Silva, L.A.A. Dye-Sensitized photo electrochemical Cells Based on Porous SnO₂/ZnO Composite and TiO₂ Films with a Polymer, Chem. Mater., 11,9: 2474-2477. (1999)

7.5.6 Research summary

COLORIMETRIC DNA BIOSENSOR BASED ON GOLD NANOPARTICLES AND INKJET PRINTED NANOCRYSTALLINE TiO₂ PHOTODETECTOR

Rohan Senadeera^{a,b}, Iwona Bernacka-Wojcik,^a Pawel Jerzy Wojcik,
^a Leonardo Bione Silva, ^a Gonçalo Doria, ^c Pedro Baptista, ^c Hugo Aguas,
^a Elvira Fortunato, ^a Rodrigo Martins^a

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 and ^b New University of Lisbon, Campus de Caparica, 2829-516 Caparica, Portugal

Introduction

Among the numerous DNA sensing technologies, the use of colorimetric methods based on aggregation of DNA-functionalized gold nanoparticles has been recognized as a promising, inexpensive, label-free and user-friendly alternative to presently used DNA detection methods such as fluorescence or radiolabel based assays. In general, a colloidal solution of gold nanoparticles (AuNPs) with diameters of 5-20 nm exhibits a red colour due to the relatively narrow surface plasmon absorption band centered at 525 nm. Aggregation of the nanoparticles caused by addition of salt (e. g. MgCl₂), shifts the absorption peak towards a longer wavelength and changes the colour of the solution to purple. Gold nanoparticles can be easily functionalized with thioled oligonucleotides, generating DNA-functionalized gold nanoprobe (herein described as Au-nanoprobes), that aggregate in similar way as AuNPs. Further the presence of a fully complementary DNA or RNA sequence as target, stabilizes the Au-nanoprobes and the solution maintains the red colour despite of the salt addition, while non-complementary targets do not prevent the aggregation of the Au-nanoprobes, resulting in a

visible change of colour from red to blue. In this context we have developed a method which consists in the comparison of colors between solutions before and after the salt addition to the Au-nanoprobes in presence of a target DNA. This method has been successfully applied to detect the presence of DNA sequences from *Mycobacterium tuberculosis*, the etiologic agent for tuberculosis. This colour changes can be observed even by naked eye. However in order to quantify it, in this study, for the first time, we have developed a low cost, user-friendly biosensor comprising a gold nanoparticle based assay and a dye sensitized nanocrystalline TiO₂ photodetector (a DSSC) which is especially suitable for developing countries. We presented also a new approach for the fabrication of dye sensitized TiO₂ photodetectors by an inkjet printing technique, a no mask and no vacuum patterning method, which is an ideal method for cost efficient mass production. For the assay, a specific DNA sequence from *Mycobacterium tuberculosis* was used.

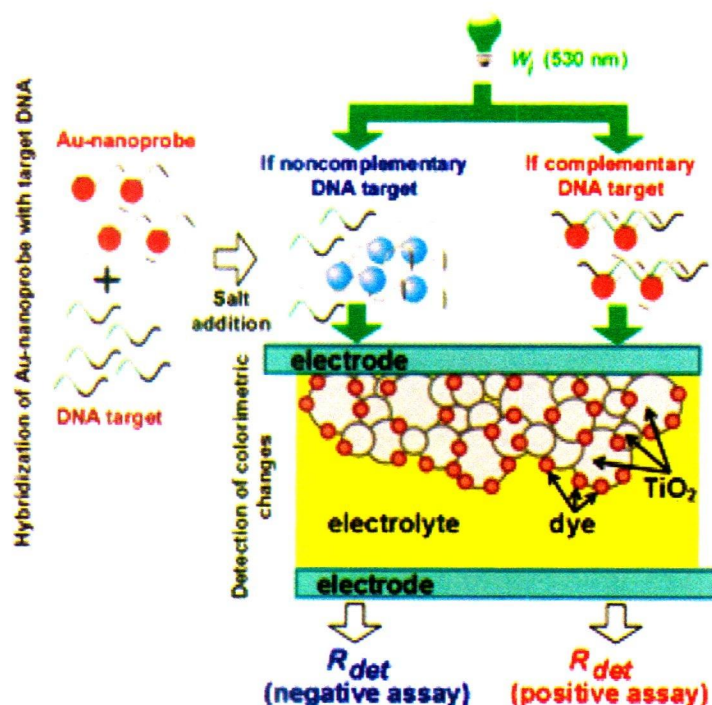


Fig.1.Schema of DNA detection of the developed biosensor.

References:

1. Regan B. O' and Graetzel, (1991). A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO_2 films., *Nature*, 353: 737-740.
2. Gratzel M. (2004), Conversion of sunlight to electric power by nanocrystalline dye-sensitized solar cells . *J. Photochem. Photobiol. A* 164: 3-14.
3. Lan, Z., Wu,J., Wang,D., Hao, S., Lin,J., Huang, Y., (2006) , Quasi-solid state dye-sensitized solar cells based on gel polymer electrolyte with poly (acrylonitrile-co-styrene) / $NaI + I_2$, *Solar Energy*, 80: 1483-1488.
4. Tennakone, K, Senadeera , G.K.R.; De Silva, D.B.R.A., (2000), Highly stable dye-sensitized solid-state solar cell with the semiconductor $4CuBr\ 3S(C_4H_9)(2)$ as the hole collector, Kottegoda, I.R.M. , *Appl. Phys. Lett.*, 77 (15), p.2367-2369,
5. Senadeera, G.K.R., Nakamura,K., Kitamura,T., Wada, Y., and Yanagida,S. (2003), Fabrication of highly efficient polythiophene-sensitized metal oxide photovoltaic cells, *Appl. Phys. Lett.*, 83: 5470—5473.
6. R.Martins, P. Baptista, L. Silva, L. Raniero, G. Doria, R. Franco, E. Fortunato. (2008), Identification of unamplified genomic DNA sequences using gold nanoparticle probes and a novel thin film photodetector. *Journal of Non-Crystalline Solids* 354 : 2580–2584.
7. Zhang, S., Raniero, L., Fortunato,E., Ferreira, I., Aguas, H., Martins, R. (2005). Amorphous silicon-based PINIP structure for color sensor, *Thin Solid Films* 487: 268–270.

7.6 ECOLOGY AND ENVIRONMENTAL BIOLOGY PROJECT

Project leader: Dr. Suresh P. Benjamin, Senior Research Fellow

Biodiversity surveys in Sri Lanka.

All research projects commenced in or around June 2009.

Biodiversity of soil arthropods

Objectives and progress of the project: The loss of quality habitats due to anthropogenic causes such as over population, habitat degradation and climate change demands the urgent attention of biologists. The primary focus of our project is thus the study of the mega diverse invertebrate fauna of Sri Lanka. The invertebrate fauna of our country remains largely unexplored, with most studies originating during the colonial period. Arthropod diversity estimates can be useful as indirect assays of ecosystem function or productivity, or as direct estimators of ecosystem responses to human induced change. Our main focus is on pseduoscorpions and spiders, animal groups of high conservation necessity. They are top predators that play a major role in controlling populations of other soil and surface dwelling organisms harmful to humans. Around 100 specimens of pseduoscorpions and 150 specimens of spiders have been collected and around 50% have been identified to generic level. All collected specimen have been cataloged. The first publication based on the results of this project is a checklist of the pseduoscorpion fauna of Sri Lanka, which is scheduled to be submitted by the end of 2010. The spider biodiversity project has resulted in three publications for this year.

the same reason. Orchids are clearly an ideal target group for conservation. We are currently conducting survey of the genera *Dendrobium* and *Bulbophyllum*. This is the first floral survey undertaken since the Smithsonian Institution initiated floral project of the 1960s. Fifteen field visits were undertaken for the year 2010. Most species of the target taxa have been collected and are in the process of being documented.

Human Resource Development

Three research assistants (Sudesh Batuwita, Buddhika Perera, Harshani Sandamali) and several volunteers from all over the island are being trained as part of these projects. Research collaborations have been established with local as well as international research institutes.

7.6.1 Biodiversity of Orchidaceae.

Objectives and progress of the project: Our second focal group is orchids. Orchidaceae is one of the largest plant families in Sri Lanka, found in almost all terrestrial vegetation types and habitats. There are 188 orchid species belonging to 78 genera with one endemic genus and 55 endemic species in Sri Lanka. Forests of the lowland wet zone and the montane zone are rich in orchid diversity. Because of their beautiful flowers most orchids are ornamental plants of high economic value; sadly they are also threatened due to

7.6.2 Research summary

ECOLOGY AND ENVIRONMENTAL BIOLOGY

Suresh P. Benjamin, Tissa Herath, Sudesh Batuwita, Harshani Sandamali, Buddhika Perera, and Namal P. Atukorala

Biodiversity of soil arthropods

Deforestation, soil degradation and climate change adversely affect sensitive organism like soil arthropods. Thus, the study and assessment of conservation status of soil arthropods are imperative. Sri Lanka's diverse invertebrate fauna is remains largely unexplored. Most of the studies concentrated on invertebrates were published during the colonial period. Our present study of the pseudoscorpion fauna of Sri Lanka is the first of its kind to be conducted by Sri Lankans and is after 27 years since the publication of Beier's review of the pseudoscorpion fauna of Sri Lanka.

The present survey has collected 46 species of pseudoscorpions previously recorded from Sri Lanka (Table 1). We have also recorded a new family and several new species. Out of the recorded 46 species, nineteen species (43%) are endemic to Sri Lanka. Thirty field trips have been carried out during the period of Aug 2009 to Aug 2010, which yielded 350 specimens belonging to 12 families and representing 24 species (> 50% of Sri Lanka's recorded diversity).

First publication based on the results of the Pseudoscorpion biodiversity project is a checklist of fauna of Sri Lanka, which is scheduled to be submitted by the end of 2010. The spider biodiversity project has resulted in the 3 publications for this year.

Floristic survey of economically important Orchids of the genera *Bulbophyllum* and *Dendrobium*.

Orchid diversity is richest in mountain and low land wet zone forests in Sri Lanka. Therefore fifteen field visits were undertaken in the period of January 2010 to October 2010 study species of *Dendrobium* and *Bulbophyllum* with a special focus towards the Knuckles region. We have found five species of

Dendrobium out of eight and six *Bulbophyllum* out of eleven species present in Sri Lanka.

Vegetative traits of these specimens were measured using a vernior caliper and a measuring tape and dissected floral parts were drawn with the aids of stereomicroscope equipped with a camera lucida. All together three *Dendrobium* species and one *Bulbophyllum* species have been illustrated. These four specimens have been photo documented as well. One objective of this survey is to determine host plant specificity. In this regard forty three herbaria have been prepared for host plant identification. Chromosome of the *D. aphyllum* specimens from various localities are being conducted. We are also developing methods to tissue culture *D. aphyllum*. We have grown shoot meristoms of *D. aphyllum* in "Vacin and went".

A Comparative Survey on Phytoplankton and Zooplankton in Sri Lankan Reservoirs

Plankton survey will cover the four major climatic zones (wet zone, intermediate zone, dry zone and arid zone) in Sri Lanka. 79 sites in 48 reservoirs (in 8 districts, Anuradhapura, Pollonnaruwa, Puttalama, Baticaloa, Ampara, Kandy, Matale and Nuwar Eeliya) have been sampled so far. Plankton in the collected samples indentified during the whole 2010. However, identification is constrained due to the lack of a dedicated identification guide for Sri Lanka. This survey has recorded the presence of 90 plankton species in Sri Lanka, of which 60 are species of phytoplankton, and 23 are species of zooplankton. 83 species have been indentified and can be categorized as follows: 32 – Chlorophyceae, 02 – Euglenophyceae, 01- Xanthophyceae, 13 – Cyanophyceae, 10 – Bacillariophyceae and 01- Dinophyceae are phytoplankton and 07 – Rotifera, 10 – Cladocera, 02 – Ostracoda and 04 – Copepoda are

zooplankton. 07 species in our collection are unidentified, highlighting the need for further taxonomic work in the area. The highest number of recorded phytoplankton were Chlorophytes while the highest number of zooplankton were Cladocerans. All species were photo documented and will be used for the plankton guide.

Ecological studies in the Sam Pophams Arboratum

This Arboretum could be considered a nationally important forest out of the two established in Sri Lanka, one in the Wet Zone in Hiniduma and this one in the Dry Zone. Sam Pophams Arboratum is opened to the public, school children and Scientists who are interested conducting research on the fauna, flora or any other form of research related to the environment. At present some scientists of our institution are already engaged in research especially on soil, litter and insects. In addition to the land of 7 acres donated by Mr. Sam Popham, the IFS acquired adjoining land extending the Arboretum to 34 acres. On this basis it has now become an ideal place for undergraduates, graduates and researchers to conduct work especially on flora and fauna succession. For this purpose negotiations were made with the Lecturer in charge of ecological studies and the dean of the Faculty of Applied Sciences, Rajarata University, Mihintale, to monitor and record plant and animal succession annually utilizing the undergraduates and post graduate students offering courses in Ecological studies/programs.

References

1. Beier, M.(1973). Pseudoscorpionidae von Ceylon. Entomologica Scandinavica Suppl. 4, 39-55.
2. Benjamin S. P. (2010). Revision and cladistic analysis of the jumping spider genus *Onomastus* (Araneae, Salticidae). Zoological Journal of the Linnean Society 159: 711-745.
3. Benjamin S. P. and G. Hormiga. (2009). Phylogenetic placement of the enigmatic genus *Labullinyphia* van Helsdingen, 1985, with redescription of *Labullinyphia tersa* (Simon, 1894) from Sri Lanka (Araneae: Linyphiidae). Contributions to Natural History. 12: 161-181.
4. Benjamin S. P. and Jaleel Z. (2010). The genera *Haplotmarus* Simon, 1909 and *Indoxysticus* gen. nov.: two enigmatic genera of crab spiders from the Oriental region (Araneae: Thomisidae). Revue suisse de Zoologie 117: 1-9. (First author with Ziyad Jaleel).
5. Dimitrov D., Hormiga G. and S. P. Benjamin. (2009). A revised phylogenetic analysis for the genus *Clitaetra* Simon, 1889 (Araneae, Nephilidae) with the first description of the male of the Sri Lankan species *Clitaetra thisbe* Simon, 1903. Bulletin of the Museum of Comparative Zoology 159: 301-323.
6. Dissanayake, M.D. and Fosberg, F. R. (1981). A Revised Handbook to the Flora of Ceylon. (Vol: II). Amerind Publishing. New Delhi. Pp.4-113.
7. Moldenke, A., M. Pajutee and E. Ingham. (2000). The functional roles of forest soil arthropods: the soil is a lively place, proceeding of the California Forest Soils Council Conference on forest soils biology and forest mangement, February 23-24, 1996, Sacramento, California.
8. Edwards G. B. and S. P. Benjamin. (2009). A first look at the phylogeny of the Myrmarachninae, with rediscovery and redescription of the type species of *Myrmarachne* (Araneae: Salticidae). Zootaxa 2309: 1-29.
9. Fernando, M. Wijesundara, S. Fernando, S. (2003). Orchids of Sri Lanka. IUCN. Sri Lanka. pp.1-20.
10. Foelix, R. F. (1996). Biology of Spiders. 2nd edn, Oxford University Press.
11. Harvey, M.S. (2009). *Catalogue of the Pseudoscorpionida*. Manchester University Press: Manchester.
12. Harvey, M. S. (1992). The phylogeny and classification of the Pseudoscorpionida (Chelicerata: Arachnida). *Invertebrate Taxonomy* 6, 1373-1435.
13. Weygoldt, P. (1969). *The biology of pseudoscorpions*. Harvard University Press: Cambridge, Massachusetts.

7.7 GEOTHERMAL RESOURCES MAPPING PROJECT

Project leader: Dr. N. Deepal Subasinghe, Senior Research Fellow

Mapping of geothermal resources

Objectives and progress of the project:

Geothermal mapping project was started in August 2009. Geothermal energy is one of the most promising renewable energy resources available to us in Sri Lanka. There is very little information currently available on this resource. Our geothermal resources mapping project will fill this gap. The main objectives of this project are to identify and characterise known sources of geothermal hot spots in Sri Lanka; to evaluate the geothermal resources in the light of their potential for economic development, especially for electricity generation; to produce a geothermal resource map of Sri Lanka, to investigate the Highland-Vijayan boundary as a possible mini plate-boundary and, to develop collaboration with world experts and obtaining their knowledge and expertise in latest techniques.

An extensive field survey was completed using latest non-invasive electro-magnetic techniques and collected a huge amount of data. Analysis of data is in progress now.

Once completed, geothermal resource map will be useful to the government or any private organisation to understand the commercial potential of each hot spring. This will lead to develop geothermal power plants or use the hot springs for recreational and other uses.

During the field work, a number of young scientists received extensive training in field mapping and latest electro-magnetic (EM) techniques such as magneto-telluric (MT) and Time Delayed EM (TDEM).

Grants

National Environmental Research Council, UK (NERC) approved a loan of MT and TDEM equipment to be used in Sri Lanka. Approximate commercial rental value is about Rs. 3 Million.

Grant no. GEFSC Loan 915 (from NERC, UK)

Collaborations

Prof. Bruce Hobbs, Edinburgh University and PGS, UK., Dr. G.M. Fonseka from Canada and Geological Survey & Mines Bureau, Sri Lanka.

Prof. W. Siripunvaraporn of Mahidol University, Thailand agreed to accept 1 or 2 research assistants for up to 1 year duration, to train on MT data analysis. Commercial interests were expressed by Soil Tec Pty Ltd and Hairu Engineering Consultancy Pty Ltd. Initial discussions were successful.

Human Resource Development

T.B. Nimalsiri - Registered for MPhil at Univ. Peradeniya

N.B. Suriyaarachchi - Registered for MPhil at Univ. Peradeniya

7.7.2 Research summary

GEOPHYSICAL INVESTIGATION ON GEOTHERMAL RESOURCES IN SRI LANKA

N.D. Subasinghe¹, N.B. Suriyaarachchi¹, T.B. Nimalsiri¹, B.A. Hobbs², G.M. Fonseka¹ IFS, Kandy² Department of GeoSciences University of Edinburgh, UK**Introduction**

As the world energy demand is rapidly increasing, the fossil fuel and other non-renewable resources are declining at an alarming rate. Currently 87% of world energy is supplied by non-renewable resources (coal, oil, gas and uranium) and these energy sources will have to be substituted in not-so-distant future (Grasby, 2009). This is also the case in Sri Lanka, where fossil fuels dominate the energy sector. Worse is that Sri Lanka has to depend on imported fuel for most of its energy requirements.

This fact has aroused the interest in alternative, renewable energy supplies. Having almost exhausted our hydroelectric power generation potential, we need to look for non-conventional renewable resources. Of all the resources, geothermal energy has some of the most significant potential. Unlike other renewable energy sources such as hydro- wind, wave and solar electricity, geothermal energy does not depend on weather and provides steady stream of energy 24 hrs a day all around the year. Geothermal energy has the added advantage of emitting zero or very little green house gases and a plant can be established in any sensitive environment such as a farm, forest, residential area or in a city.

Recent technological advances have reduced the temperature gradient required for power generation which in turn has reduced the depth required to access the resource and broadened the area where the resource is available. There are a number of thermal springs in Sri Lanka and these have seen associated development of recreational and tourist facilities. However, there was very little information available on the geothermal resources in Sri Lanka.

One of the main reasons for not conducting a detailed investigation earlier in Sri Lanka on geothermal potential was the lack of advance technology and

know-how required for such an investigation. Direct measurement using bore holes will be very useful, however the cost is prohibitive. *Magneto-telluric (MT)* investigation that uses passive electromagnetic techniques to explore deep into the earth is a non-invasive, relatively less expensive method. Since we did not have the necessary equipment and expertise in Sri Lanka, we invited some of the world experts from the UK and Canada with equipments.

There are two major objectives to this project:

1. investigating the geothermal resources and understanding their potential for the benefit of the country.
2. understanding the boundary between two major lithological regions of Sri Lanka

In this paper, we present and discuss some of the preliminary results from the geophysical survey we conducted in Sri Lanka. This is also the first ever MT survey in Sri Lanka.

Geological Setting

Sri Lanka is located in a Precambrian shield zone which can be divided into three major lithological zones: Vijayan complex to the SE, Wannai complex towards NW, and Highland Complex between them. A belt of Miocene limestone rocks overlie the Precambrian rocks in the N-NW. Base rocks in Sri Lanka are mainly crystalline metamorphic rocks. Highland Complex predominantly consist of granulite facies metasedimentary rocks such as quartzite, marble, amphibolites gneiss and charnockitic gneiss, while the Vijayan complex consists mainly of granitic gneisses, pegmatite gneiss, calc gneiss, quartzite and dolerite intrusions (Hobbs *et al* 2010). A significant number of thermal springs are located along a N-S trending zone between two major lithological zones.

of Sri Lanka's highest gravity low (Hatherton et al., 1975) and one of the models suggested is block faulting, considered as a graben or crustal down warp. Alternatively the boundary is seen as a major thrust zone during the collision between East and West Gondwana (Kroner, 1991).

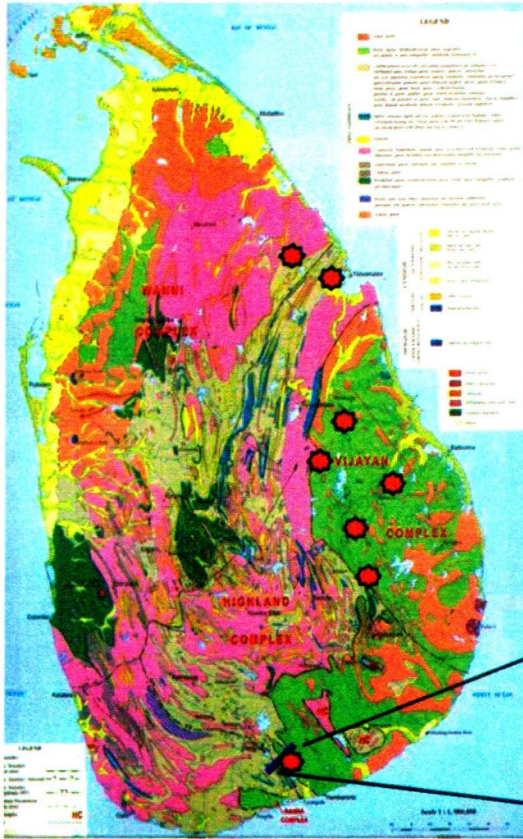


Figure 1. Geological map of Sri Lanka showing major lithological zones. Red stars show MT locations. Blue line indicates the Mahapalassa traverse across two lithological zones.

Methodology

MT survey: Magneto-telluric surveys were conducted along traverses on predetermined locations. Whenever possible, these traverses were selected along a straight line, perpendicular to the existing geological features such as faults and fractures as determined by the existing data.

Attempts were made to maintain the distance of approximately 1 km between two MT sites on a given traverse; however, due to practical reasons this was not always possible.

A base station was maintained on each traverse while one or two mobile MT stations were in operation. It was necessary, at certain locations, to record the readings over a span of 48 hours, in order to reach the depth of several hundred kilometers, which is needed

to achieve the second objective.

Time Delayed Electromagnetic Survey (TDEM):

While MT provides information from the depths up to hundreds or even thousands of kilometers, it is necessary to get more detailed information on the first few hundred metres. In order to collect such information, TDEM surveys were conducted at the same locations as the MT.

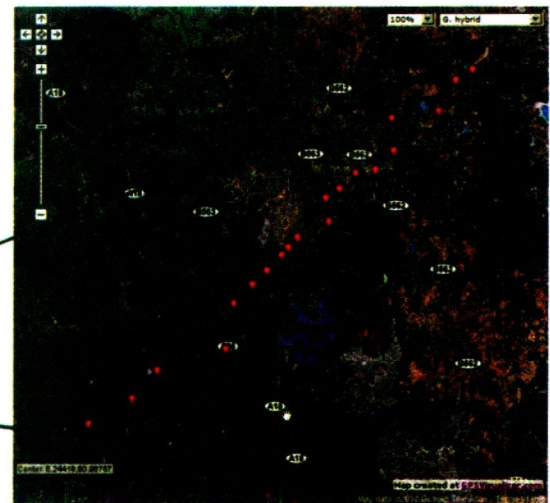


Figure 2. Locations of survey sites around Mahapelessa hot spring. This traverse is marked as a blue line on Fig. 1.

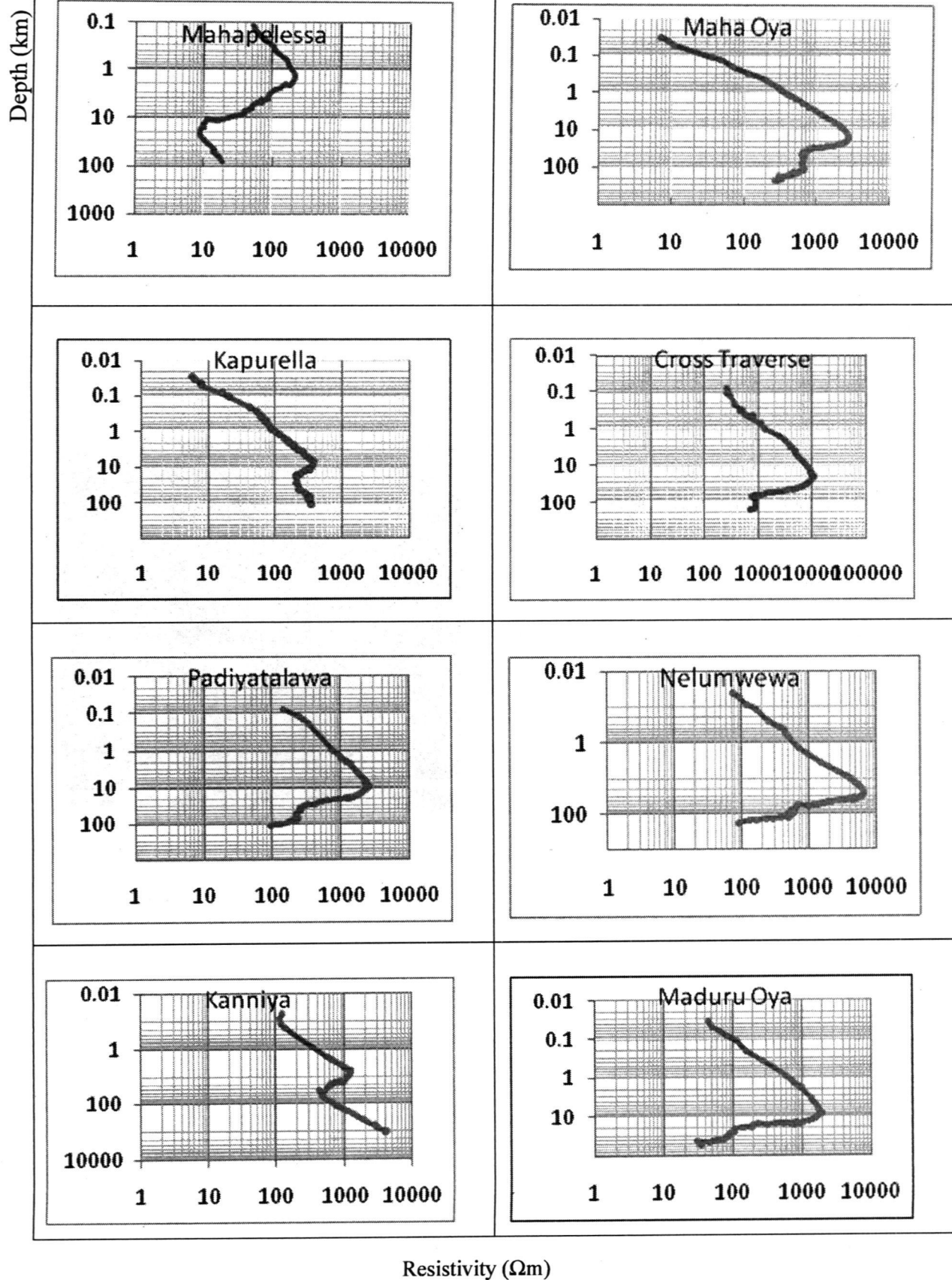


Figure 3. Variation of resistivity with depth at certain selected sites. Sharp changes of resistivity indicate changing geological conditions. Lower resistivity may be due to water-bearing fractures or heated rocks. Note the log scale used.

MT and TDEM surveys across the Highland/Vijayan boundary in the south, passing through the Mahapalessa hot spring (Figure 2) were conducted with over 20 sampling sites covering more than 20km of traverse.

At other locations, average of about 7 sites was surveyed. Cross traverses were conducted when two locations are sufficiently close to each other.

Results & Discussion

Resistivity variations with depth at certain selected sites are presented in Figure 3. Resistivity should usually increase with depth, if there are no significant change in geological features. However, all the profiles show some deviations from the norm, indicating possible large-scale changes to the sub-surface geology. For example, the resistivity profile at Mahapalassa indicates a sudden reduction of resistivity at a depth of about 1.5km. This could possibly be the major fracture that delivers hot water to the hot spring. Decline of the resistivity continues for about 10km before it starts increasing again. At other sites lower resistivity is encountered at relatively greater depths. Low resistivity could also be due to heated rocks. Careful analysis of MT data may help identify such locations. Analysis of MT and TDEM data is a complex and time consuming process. However, conclusions should only be drawn after complete analysis of data.

Acknowledgement

Prof. B.A. Hobbs, Dr. G.M. Fonseka, Institute of Fundamental Studies, Geological Survey and Mines Bureau, National Water Supply and Drainage Board and National Environmental Research Council (NERC), UK, sponsored this work, contributing various ways. Members from Edinburgh University and other participating institutes are acknowledged for their hard work and dedication to this work.

References

1. Fonseka, G.M., 1994. Geothermal Systems in Sri Lanka and Exploitation of Geothermal Energy. J. Geol. Soc of Sri Lanka, Vol. 5 (1994) 127-133.
2. Fonseka, G.M., 2000. Geological and geophysical Investigations for Geothermal Energy, Study of Mahapelessa and Mahaoya Thermal Springs, NARESA report RG/94/EP/02 with National Science Foundation, Sri Lanka.
3. Grasby, S.E., 2009. Geothermal Energy Potential in Canada: Plenary Session, Frontiers and Innovation, CSPG CSEG CWLS Convention, Calgary.
4. Hobbs, B.A., Fonseka, G.M., Dawes, G., Johnson, N., Subasinghe, D. and Whaler, K. 2010. Geothermal and Tectonic studies in Sri Lanka using Magnetotellurics. Proceedings of the IAGA WG 1.2 on Electromagnetic Induction in the Earth 20th Workshop Giza, Egypt.
5. Hatherton, T., Pattiarachchi, D.B., and Ranasinghe, V.V.C., 1975. Gravity map of Sri Lanka: Prof. Pap., No. 3, Geol. Surv. Department, Sri Lanka, 40p
6. Kroner, A., 1991. African linkage of Precambrian Sri Lanka, *Geologische Rundschau*, 80, 429-440.
7. Simpson, F. and Bahr, K., 2005. Practical Magnetotellurics, Cambridge University Press, Cambridge.

7.8 MICROBIAL BIOTECHNOLOGY

Project leader: Prof. G. Seneviratne, Research Professor

7.8.1 Development of biofilmed biofertilizers (BFBFs) for applications in agriculture

The objectives of the project are to introduce BFBFs for improvement of different types of agricultural crops and to reduce the use of chemical fertilizers and agrochemicals. Use of BFBFs in agriculture will save foreign exchange spent on fertilizer imports and will help to conserve the environment. The progress of this project involving different applications of BFBFs are summarised below.

This project commenced in 2005 with the development of BFBFs for use in tea plantations. Different formulations of BFBFs for tea were developed and tested under nursery and field conditions with the collaboration of the Tea Research Institute (TRI). Three BFBFs formulations for tea are ready for commercial production with a local entrepreneur. Optimization of conditions and costs for a commercial manufacturing process of BFBFs that can be transferred to industry, have been worked out. Biofilms of one type of BFBF developed for tea was found to be successfully attached to tomato, capsicum, leafy cabbage and lettuce root systems and enhanced their N_2 fixing potential. This showed versatility of BFBFs. Plant growth parameters and photosynthetic rate were significantly higher in the BFBF treated plants.

Bacterial strains that were isolated for use in rice, common bean, green gram and maize were screened for their N_2 fixing potential and organic acid production. For rice two formulations were developed for soil and foliar application. The efficacy of the formulations was tested under field conditions at the Rice Research & Development Institute (RRDI) at Bathalagoda.

The two formulations of BFBFs developed for soil application in rubber were tested under greenhouse conditions at the Rubber Research Institute (RRI) at Agalawatte. Two BFBFs developed for seed application in common bean, were isolated from rhizobial and fungal strains associated with bean roots and root nodules, and tested in a farmer's field at Mailapitiya. BFBFs for green gram are being developed for testing. Different formulations of BFBFs for maize are being tested under greenhouse and farmers' field conditions.

7.8.2 Effect of BFBFs on Deniyaya tea die-back

The objective of the project is to determine the i) cause of chronic death of tea bushes in Deniyaya, ii) the phytotoxicity of soils, iii) to evaluate microbial activity and iv) to rehabilitate collapsed microbial communities using BFBFs on Deniyaya soils. It was found that chronic plant death is caused by accumulated phytotoxins while soil microbial activity was found to be very low. The use of BFBFs would rehabilitate microbial communities and ensure healthy plant growth. Significant recovery of plants was achieved within 2-3 months after application of BFBFs.

7.8.3 Effect of soil tannin-fertilizer interaction on allelopathic amide production

It was found that soil tannin-nitrogen fertilizer interactions produced allelopathic amides which acted as phytotoxins. Indiscriminate use of chemical fertilizers could lead to formation of phytotoxins in the soil resulting in declining yield of crops, low productivity and die-back of crops.

7.8.4 Glyphosate biodegradation by BFBFs

BFBFs were found to have the ability to biologically degrade weedicides such as Glyphosate. This would lead to reduced levels of Glyphosate in exported tea and in the environment. A new method using FT-IR spectroscopy was also developed to detect the presence of Glyphosate in plant tissues.

During these projects collaborations were established with scientists from national research institutes such as the TRI, RRI and RRDI and the national Universities.

Human Resource Development included the training of Research Assistants (03), postgraduate students (04), University undergraduates (03), and pre-University students (01) in the use of research methodologies and techniques for the study and production of BFBFs

Results

After numerous studies, we have now developed three formulations of the BFBFs for tea, which are ready for commercialization. They can replace 50% of recommended chemical fertilizer use in tea nurseries as well as estates. We are planning to start commercial production of these biofertilizers early 2011, in collaboration with a local entrepreneur.

To date, we have found that the BFBFs formulations can replace 50% of chemical fertilizers in lowland rice too, as revealed during Yala 2010 at Bathalagoda.

Initial positive response of the developed BFBFs was observed for nursery rubber. We developed a BFBFs for common bean, which is now ready for medium scale field testing. We have identified effective microbes for developing BFBFs for green gram. For maize, we have developed two formulations of the BFBFs, which are being tested in pot trials and under the field conditions.

Grants:

Funded by the IFS, TRI, RRDI, RRI, University of Peradeniya and Agrarian Services Department (ASD), Hasalaka.

Collaborations:

A. Jayasekara and Dr. L. De Silva of the TRI; S.N. Jayawardana and A. Subasinghe of the RRDI; R. Hettiarachchi of the RRI; C.M. Peries of the Uva Wellasa University; M. Ariyaratne of the University of Peradeniya; Amith and Damayanthi of the ASD.

Human Resource Development

Lasantha Herath, N. Weeraratne and U.V.A. Buddhika, Research assistants of the IFS, C.M. Peris, Final year student of the Uva-Wellasa University, M. Ariyaratne, Final year student, Faculty of Sciences, University of Peradeniya.

K. Manikdiwela, H Ariyawansa, K. Pushpitha of the PGIA, University of Peradeniya, A. Nalaka and V. Kokulan of the Faculty of Agriculture, University of Peradeniya.

W. Jayasinghe (Valunteer)

7.8.5 Research summary

FROM TRADITIONAL AGRICULTURE THROUGH CONVENTIONAL AGRICULTURE TO FUTURISTIC AGRICULTURE: SCIENTIFIC BASIS AND PROSPECTIVE DIRECTION

Gamini Seneviratne¹, A. P. D. A. Jayasekara², and S.A. Kulasooriya

¹Microbial Biotechnology Unit, IFS, ²Tea Research Institute of Sri Lanka, Hantana, Kandy

Traditional agriculture

In the past, our ancestors cleared a patch in a natural forest and cultivated crops for their foods. After few years, a gradual decline in crop yields was noticed. Then that location was abandoned and moved to another forest patch. In the abandoned forest patch, natural vegetation started to grow. After 10-15 years or so, the farmers were able to return to the original forest patch and repeat the same practice with a good yield.

Conventional agriculture

The farmers were not able to continue the above practice with the increase of the human population and consequent demand and pressure on land use. New methods had to be adopted to use land continuously for sustained crop production, if the demand was to be supplied. With onset of the green revolution, they found some answers. This was mainly the use of high yielding crop varieties, chemical fertilizers and mechanized tillage.

Fig. 1. Slow death of (a) tea and (b) coconut plants at Deniyaya and Weligama, respectively.

However after using these practices for sometime it was noticed that the crops were very susceptible to pests and diseases. Pest and disease outbreaks were accompanied by weed infestation

This led to heavy use of agrochemicals to control pests, diseases and weeds. After a few decades, decline of yield, particularly in perennial crops like tea, coconut etc. was observed. Total plant death was observed in some instances (eg. plant death of tea at Deniyaya, and coconut at Weligama) (Fig. 1). Crop response to chemical fertilizers was also reduced.

Scientific basis

In traditional agriculture, crop yields in the cleared forest patches declined, mainly because of the collapse of fungal biomass in the soil. Tillage and exposure to high temperatures and sunlight in mono- or mixed cultures of crops, leads to depletion of soil organic matter. When the forest patch was abandoned, plants emerging during the fallow period provided a range of carbon sources through root secretions that supplied microbial food and revived diverse fungi and the microbial community in the soil. Therefore, the

farmers could return to the original forest patch after a decade or so.

In conventional agriculture, mechanized tillage and chemical fertilizers heavily deplete soil fungi and bacteria, respectively (Fig. 2 a). The high yielding crop varieties exhaust plant nutrients in the soil. In general, bacteria like *Pseudomonas*, *Rhizobia* etc. release some chemical compounds that induce resistance in plants against pests and diseases. The depletion of soil microbes decreases the ability of plants to resist pests and diseases. A reduced microbial community is less competent to control pests and diseases. The collapse of soil microbes also contributes to weed infestation, because microbes that secrete toxic compounds suppressing weeds are also restrained. Consequent heavy use of agrochemicals to control pests, diseases and weeds further destroys the soil microbial community. This leads to accumulation of plant growth inhibiting toxic compounds (ie phytotoxins), which are normally biodegraded by certain soil microbes, in a balanced community. This contributes to crop yield decline, even though pests, diseases and weeds are controlled by agrochemicals. Crop response to chemical fertilizers is reduced when soil microbes are suppressed, because they play an important role in temporary fertilizer nutrients conservation and their slow release to the soil, allowing plants to take up nutrients slowly.

Fig. 2. Bacteria isolated from (a) chemically fertilized soil and (b) biofilm-based biofertilizers (BFBFs) applied soil. White spots are bacterial colonies.

Future direction

Therefore it is clear that the collapse of soil microbes due to conventional agricultural practices has led to deterioration of agriculture. If the present yield levels are to be maintained, the use of conventional agricultural practices cannot be discontinued in order to halt their negative effects on agriculture. Therefore, replenishing microbes in conventional agriculture is a must for sustained crop production.

Fig. 3. Tea plant growth at Hantana nursery of the TRI

This can only be achieved by adding microbes to the soil as biofertilizers. The Microbial Biotechnology Unit (MBU) of the IFS has developed microbial communities or biofilm-based biofertilizers (BFBFs) for this purpose (Seneviratne *et al.*, 2009) and tested in collaboration with the TRI in tea nurseries and estates. Very positive results have been obtained. It was found

that BFBFs can replace 50% of chemical fertilizer use in tea cultivation (Fig. 3) while increasing soil organic matter and reducing stresses against pests, diseases, phytotoxins and drought. Tea plant death at Deniyaya is also being recovered with the BFBFs application (Fig. 4). The MBU plans to introduce BFBFs as a commercial product to Sri Lanka in the near future and are now being tested for application to other crops like rubber, rice and maize.

Reference

Seneviratne, G., Thilakaratne, R.M.M.S., Jayasekara, A.P.D.A., Seneviratne, K. A. C. N., Padmathilake, K. R. E. and De Silva, M.S.D.L. (2009). Developing beneficial microbial biofilms on roots of non-legumes: A novel biofertilizing technique. pp. 51-62. In: Khan, M.S., Zaidi, A. and Musarrat, J. (Eds.). *Microbial Strategies for Crop Improvement*. Springer-Verlag, Germany.

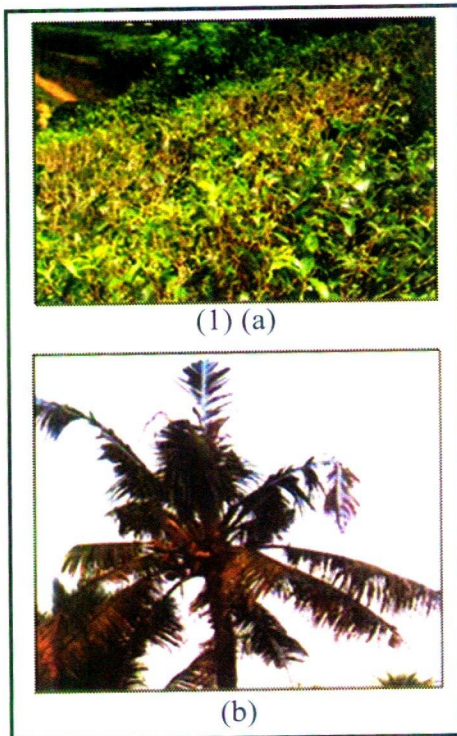


Fig. 1

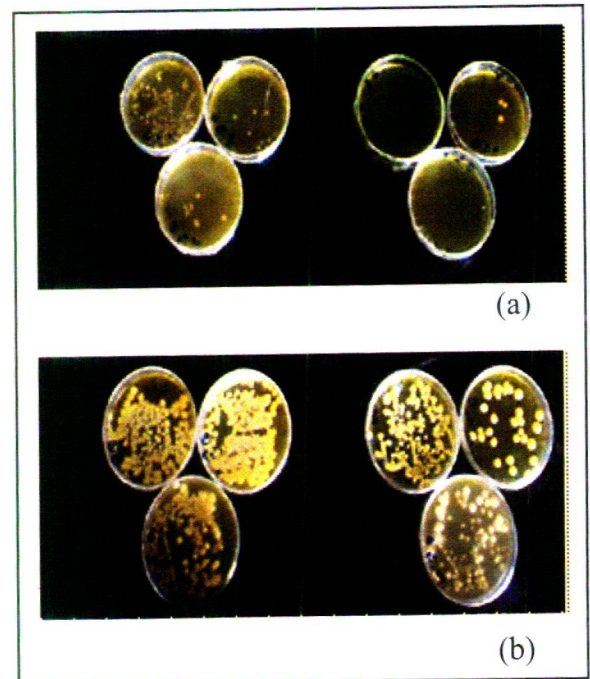


Fig. 2



Fig. 3



Fig. 4

7.9 NATURAL PRODUCT CHEMISTRY

Project leaders:

Prof. N.S. Kumar, Research Professor , Prof. U.L.B. Jayasinghe, Research Professor

Natural products are organic compounds produced by plants, fungi and other microorganisms, marine organisms and lichens. The research project on Natural Product Chemistry of IFS commenced in 1992 and has now widened in scope to include the six different areas of research described below. The overall objectives of these projects was the search for bioactive compounds from natural sources as potential resources for control of human and plant diseases.

Many bioassays were used to assess the bioactivity of extracts and compounds isolated. The DPPH (2,2'-diphenyl-1-picrylhydrazyl) assay was used to detect the presence of natural antioxidants in various extracts originated from natural sources. The brine shrimp (*Artemia salina*) lethality assay was used as a convenient probe for preliminary assessment of toxicity of a pure compound or extract. Some bioactive molecules display phytotoxicity. The degree of the phytotoxic effect of bioactive molecules can be determined using the lettuce (*Lactuca sativa*) seed germinations assay. Very few drugs are available for the treatment of fungal infections. Immunosuppressive drugs used for the treatment of eg. AIDS, leads to diseases caused by a weakened immune system in humans and an increased predisposition to fungal attack. TLC bioautography was used to detect the antifungal compounds in extracts by spraying a TLC plate with a spore producing fungus such as *Cladosporium sp.*.

During the course of the work conducted in year 2009/2010 under the six projects given below, six research assistants, five undergraduates and three pre-university students were trained in extraction and bioassays of plant and fungal extracts, separation techniques and spectroscopic techniques for identification of metabolites.

7.9.1 Plant secondary metabolites – commenced in 1992.

Chemical investigation of the hexane and ethyl acetate extracts of flowers of *Murraya koengii* yielded five pure compounds. Determinations of bioactivities of

isolates are in progress. Antifungal, antioxidant, cytotoxic, phytotoxic and mosquito larvicidal activity of twelve edible grains of Sri Lanka have been studied. Horse gram, *Dolichos biflorus* (Kollu), is found in Sri Lanka and neighboring countries, and is well known for its medicinal properties. Chemical investigation of Kollu is in progress.

7.9.2 Fungal toxins and metabolites.

This study of fungal metabolites from fungal species isolated from healthy and diseased fruits found in Sri Lanka, commenced in 2009. Pure cultures of fungi were isolated from fruits of *Musa sp* (ambul), *Persea americana* (avocado), *Flacourtia indica* (ugurassa) and *Limonia acidissima* (woodapple). Each pure fungal sp. was cultured in different media (rice, potato dextrose agar and potato dextrose broth). The fungal mycelia and the media that were used for culturing were extracted with ethyl acetate and methanol to isolate fungal metabolites. Biological assay of extracts and isolation of fungal metabolites using chromatographic methods, is in progress.

7.9.3 Microbial Transformations commenced in 2009

Ambrosia fungus, *Monacrosporium ambrosium*, is a symbiotic fungus of Shot hole borer (SHB) beetle (*Xyleborus fornicatus*), which is a major pest in tea plantations. Previous studies have shown that caffeine, the major alkaloid found in tea, has a toxic effect on SHB and an inhibitory effect on ambrosia fungus. Experiments are being carried out to determine whether structural transformation of caffeine and/or new metabolites are produced by ambrosia fungus in the presence of caffeine. Laboratory culture media which contain different concentrations of caffeine were inoculated with pure cultures of *M. ambrosium*. Culture media will be extracted with organic solvents and studied after 4-6 weeks.

7.9.4 Proanthocyanidins from tea and fruits.

This project commenced in 2009. Proanthocyanidins are powerful antioxidants and are constituents of fresh fruits and other plant parts. These compounds would be useful food additives but are highly reactive and unstable. The aim of this project is to identify readily available sources of proanthocyanidins from edible and to then prepare stable derivatives from these plant extracts. The juice, seeds and peel of *Punica granatum* (delum) and *Flacourtia inermis*, (lovi) were extracted with aqueous 80% acetone, separated into fractions by solvent extraction and then tested for the presence of proanthocyanidins. Bioassays to detect antioxidant activity are in progress. Stable derivatives of suitable proanthocyanidin samples will be prepared.

7.9.5 Chemistry and bioactivity of edible fruits of Sri Lanka - commenced in 2007

Edible fruits are a potential source of environmentally friendly bioactive compounds since toxicological issues are remarkably less than in other natural sources. Some popular edible fruits of Sri Lanka that are being investigated include *Aegle marmelos* (beli), *Syzygium samarengansis* (jambu), *Annona muricata* (katuanoda), *Annona reticulata* (welianoda), *Flacourtia indica* (uguressa) and *Pouteria campechiana* (lavulu), *Garcinia cambogia* (goraka) and *Musa* (banana) sp. etc. This work led to the isolation of various classes of compounds including some novel natural products with biological activity.

7.9.6 Value added products from the under-utilized fruits of Sri Lanka – commenced in 2009.

Garcinia cambogia (goraka) found in the lowland tropical rainforests of Sri Lanka and in many home gardens, has been used in Sri Lanka for culinary and medicinal purposes for centuries. Various parts of the tree are used in Ayurveda medicine because of its therapeutic and antiseptic properties. Goraka is in high demand in the current world market as a nutraceutical because of its potential as a dietary supplement used for weight loss and appetite control. This study commenced in 2009 to identify and quantify constituents, which will be subject to several new bioassays including enzyme inhibition assays in order to

understand its economic potential as a food additive and a nutraceutical.

Human Resources Development

A workshop titled “*Bioassays for Natural Products Research*” was organized by the Natural Products Chemistry Research group of the Institute of Fundamental Studies (IFS), and was held on 25th-26th of March, 2010. Over thirty participants representing University of Colombo, University of Sri Jayawardenapura, University of Kelaniya, University of Ruhuna, Uva-Wellassa University, University of Jaffna, Tea Research Institute (TRI) and the IFS attended the workshop. Experts from the IFS, Institute of Chemistry Ceylon, University of Peradeniya, University of Kelaniya, Department of Agriculture and the Industrial Technological Institute (ITI) served as Resource Persons. Proceedings of the Workshop were collated into a booklet and distributed to the participants.

Postgraduate Research Assistants registered for M.Phil degrees.

Ms. A.G.A.W Alakolanga, Ms. A.M.D.A. Siriwardana, Ms. H.M.S.K.H. Bandara, Mr. K.G.E. Padmatilleke and Ms. G.E.H. de Silva
Mr. D.S. Jayaweera, Senior Staff Technician

7.9.7 Research summary

FUNGAL SECONDARY METABOLITES - ISOLATION AND BIOACTIVITY

N.S. Kumar and U. L. B. Jayasinghe

Introduction.

Why is there a need to study fungal metabolites? Fungi occur in varied ecological habitats and exert a wide influence on plant physiology and biochemistry. Endophytic fungi, which reside in the tissues of living plants and epiphytic fungi that inhabit plant surfaces, are considered as potential and relatively unexplored sources of novel bioactive natural products. The most well-known example of a biologically active fungal metabolite is the widely used antibiotic penicillin, which was first isolated from cultures of *Penicillium notatum* by Alexander Fleming in 1928.

Unlike pathogenic fungi, endophytic fungi exist in mutualistic association with their host plants. Endophytic fungi produce important secondary metabolites¹². The discovery by Stierle *et al.*³ that the endophytic fungus of *Taxomyces andreanae* of the yew plant *Taxus brevifolia* produced anti-cancer drug taxol, suggested that endophytic fungi could be an important alternative source of plant secondary metabolites.

The aim of this project was to study cultures of fungi isolated from healthy and diseased fruits as an important source of plant and fungal secondary metabolites. The fungi were cultured in different media. Extracts of the fungi and the media were subjected to bioassays and studied to detect the presence of biologically active fungal metabolites. Fungal metabolites were separated using chromatographic methods.

Results

Several epiphytic and endophytic fungi were isolated from fruits of *Limonia acidissima* (Divul), *Flacourtia indica* (Ugurasse), *Persea americana* (Alipera) and *Musa* sp (Banana 'ambul'). Fungi were isolated on potato dextrose agar (PDA) medium. An *Aspergillus* sp was isolated from the seeds of wood apple as a white yellowish mycelium with black

from diseased fruit of *Musa* sp.

Pure cultures of fungi were grown on different types of media (solid media-rice, liquid media – PDB, semi-solid media - PDA) and allowed to incubate for 3-4 weeks and then extracted in to the solvents *n*-hexane, EtOAc, MeOH respectively. These extracts were subjected to bioassays for antioxidant activity against DPPH radical scavenging by TLC-bioautographic method, cytotoxicity against brine shrimp (*Artemia salina*) lethality assay, phytotoxicity against lettuce (*Lactuca sativa*) seed germination assay and antifungal activity against *Cladosporium cladosporides* by TLC - bioautographic method. Results of the bioassays are given in Table 1.

These results reveal that the fungal extracts are potential sources for the isolation of antioxidant, cytotoxic, phytotoxic and antifungal compounds. In order to isolate bioactive compounds activity guided fractionation of fungal extracts are in progress.

spores on PDA medium. A pink mycelium with a white margin (B) and another with a white woolly mycelium were isolated from Ugurasse fruit.

An epiphytic black filamentous fungus was isolated

Table 1. Bioactivity of Fungal extracts

Fruit	Fungs	Medium	Bioactive extracts	Bioactivity
Wood-apple	<i>Aspergillus</i> sp	PDB	EtOAc	Antioxidant, Phytotoxic Cytotoxic
		PDB mycelium	EtOAc, MeOH	
Ugurassa	UF ₁ <i>Colletotrichum</i> sp	Rice PDB	Hexane, EtOAc, MeOH Hexane, EtOAc	Antioxidant, Phytotoxic Antioxndant Antioxidant Phytotoxic Antioxidant
	UF ₂ <i>Colletotrichum</i> sp	Rice PDB PDA	Hexane, EtOAc, MeOH Hexane, EtOAc EtOAc, MeOH	
	UF ₃ Family Moralase	Rice	Hexane, EtoAc, MeOH	
Banana- "Ambul"	<i>Aspergillus</i> up	PDB PDA Rice	EtoAc EtoAc Hexane, EtOAc, MeOH	Antioxidant, Cytotoxic, Phytotoxic Antioxidant, Cytotoxic, Phytotoxic Antifungal, Phytotoxic
Avocado fruit pulp	AF	Rice PDB	Hexane, EtOAc, MeOH Hexane, EtOAc	Antioxidant, Phytotoxic Antioxidant, Cytotoxic
Avocado	Ap1	Rice PDB	Hexane, EtOAc, MeOH Hexane, EtOAc	Antioxidant, Cytotoxic Phytotoxic Phytotoxic
Avocado peel	AP2	Rice PDB	Hexane, EtOAc, MeOH, Hexane, EtOAc	Antioxidant, Cytotoxic Phytotoxic

References

1. B. Schulz, B. Christine., (2006) *Mycol. Res.*, 109 661-686.
2. A.A.L. Gunatilaka (2006) *J. Nat. Prod.* 69 509-526 3. A. Stierle, G. Strobel, D. Stierle (1993) *Science* 260, 214-216

7.9.8 Research Summary

Chemistry and bioactivity of some edible fruits of Sri Lanka

U.L.B. Jayasinghe and N. S. Kumar

Introduction

Indigenous fruits of Sri Lanka have been used for their medicinal properties and as a source of nutraceuticals from ancient times. These fruits have potential as food and cash crops, because the fruit trees require little capital outlay or external input and are well adapted to local conditions. Some popular edible fruits of Sri Lanka that are being investigated include *Aegle marmelos* (Beli), *Artocarpus altilis* (Del), *Artocarpus nobilis* (Wal-del), *Averrhoa carambola* (Kamaranga), *Flacourtia indica* (Uguressa) and *Flacourtia inermis* (Lovi), *Pouteria campechiana* (Lavulu), *Garcinia cambogia* (Goraka) and *Musa sp.* (Banana). This work led to the isolation and structure elucidation of various classes of compounds including some novel natural products with biological activity.

Pouteria campechiana (s. *Lavulu*) of the family Sapotaceae is a popular edible fruit found in Sri Lanka and South Asian countries. A preparation from seeds is used as a remedy for ulcers and a decoction from bark is used for skin eruptions in Cuba. Several bioactive constituents have been reported from the genus *Pouteria*. Some carotenoids and some antioxidant polyphenolic compounds have been reported from fruits of *P. campechiana*.

Banana is used medicinally to ease digestion, vitalization of the body, decrease pain due to wounds in the digestive tract, decrease constipation, in the treatment of cholera, rheumatic arthritis and allergies. In traditional medicine banana is used to decrease body weight and also in treatment of snake bite.

Garcinia cambogia is becoming a popular species in the world because of its potential as a dietary supplement for weight losses and appetite control. It is not cultivated as a fruit tree, but seen growing in wet and intermediate zone home gardens.

This paper reports some results obtained from study of extracts prepared from ripe fruits of *Flacourtia inermis*, *Pouteria campechiana*, *Garcinia cambogia* and *Musa sp.*

Results

Bioassays were used to detect antioxidant, antifungal, cytotoxic and phytotoxic activities of the hexane, ethyl acetate and methanol extracts of several edible fruits of Sri Lanka. The assays that were used were the DPPH assay (antioxidant activity), TLC bioautography and agar well bioassay (antifungal

activity), cytotoxic activity assay using 2nd instar nauplii stages of brine shrimps (*Artemia salina*), and lettuce seed germination assay (phytotoxic activity).

Fresh fruits of *F. inermis* (1.5 kg) were collected from the Central Province of Sri Lanka and extracted with aqueous 70% acetone containing 0.1% ascorbic acid. Work-up of this extract yielded an EtOAc extract and an aqueous extract. A wine red sticky solid was obtained from the EtOAc extract while the aqueous solution after dialysis (Spectra/ Por: MWCO 3500) yielded a brown solid DA1. TLC studies with *p*-dimethyl aminocinnamaldehyde (DMACA) (EtOAc : H₂O : HCOOH, 90:05:05) of DA1 indicated the presence of proanthocyanidins. FTIR spectrum revealed the presence of hydroxy (3416.6 cm⁻¹), ester (1761.6 cm⁻¹) and aromatic or α,β -unsaturated ketone groups (1687.7 cm⁻¹) in DA1. Detail analysis of ¹HNMR, ¹³CNMR, 2D-NMR and ESI-MS spectral data of DA1 suggested a polymeric structure composed of the following repeating unit (Fig. 2).

The edible part of ripe fruits and seeds of *P. campechiana*, collected from the Central Province of Sri Lanka and extracted sequentially with EtOAc and MeOH. A portion of MeOH extract (20 g) was partitioned with *n*-butanol/H₂O to give *n*-butanol extract.

Fruit pulp of seven varieties of ripe banana *Musa sp.* Ambul, Anamalu, Embun, Kolikuttu, Puvalu, Rathbala and Seeni were extracted using hexane, dichloromethane, EtOAc and MeOH.

Fresh fruits of *Garcinia cambogia* were sequentially extracted with hexane, ethyl acetate and methanol solvents.

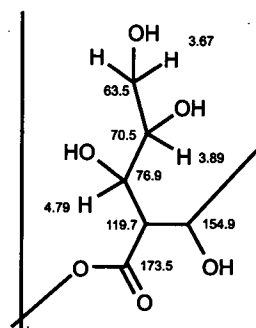


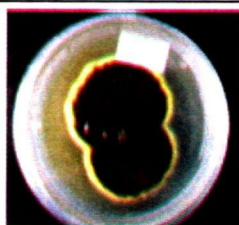
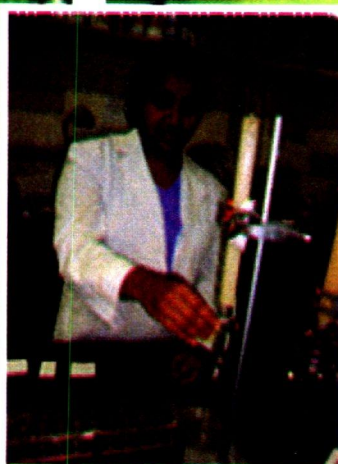
Figure 02: Structure of repeating unit of DA1

Table 1. Bioactivities of fruits of *F. inermis*, *P. campechiana* and *G. cambogia*

Species	Extract	Bioactivities
<i>F. inermis</i>	dialysed extract	antioxidant, Plant growth enhancement
	EtOAc extract (seed)	antioxidant, cytotoxic, phytotoxic
<i>P.campechiana</i>	BuOH extract (seed)	antioxidant, cytotoxic
	EtOAc extract (pulp)	antioxidant
	BuOH extract (pulp)	antioxidant
	Hexane extract	antifungal activity
<i>G.cambogia</i>	EtoAc extract	antifungal activity, phytotoxic activity
	MeOH extract	phytotoxic, activity

Table 2. Bioactivities of fruits of *Musa* sp.

Variety	Bioactivities
Kolikuttu	Highest antifungal, cytotoxic and phytotoxic activities
Ambul	Highest antioxidant activity, phytotoxic activity
Anamalu	phytotoxic activity
Rathabala	phytotoxic activity



(A) *Aspergillus* sp



(B) *Colletotrichum* sp



Fruits of *F. inermis*, *P.campechiana*,
G. cambogia and *Musa* sp.

7.10 PHOTOCHEMISTRY PROJECT

Project leader: Prof. J. Bandara, Research Professor

7.10.1 Conversion of solar energy in to electrical and chemical energies

The project commenced in 1999 aiming investigation of alternative energy resources especially solar energy. Finding alternative energy sources is now of global relevance. An alternative energy source is one that can meet the energy and current energy sources, either because it has a less polluting effect or primarily by the possibility of renewal. Since the sources of fossil and nuclear energy are finite, it is inevitable that at some point the energy (application) can not be supplied and the whole system will collapse unless we are to discover and develop new sources of energy: these would be alternative energy.

Our achievements are that we have already developed a 7% efficient solar cell and obtained a local patent. This investigation has to be further investigated in order to increase the solar cell efficiency. Apart from

that, during 1999-2010, our findings have been published in more than 35 research articles in high impact factor international refereed journals

Grants

NSF, Sri Lanka, Rs.1,000,000 (2003-2005)

NRC, Sri Lanka, Rs. 6,800,000 (2010-2012)

AvH foundation, Germany, Rs. 3,000,000 (2010)

Collaborations

Dr. J. Kiwi, Swiss Federal Institute of technology, Switzerland

Prof. M. Thelakkat, University of Bayreuth, Germany

Human Resource Development

Postgraduate Research Assistants registered for M. Phil degrees:

Mr. J. Akilawasan, Mr U.W. Pradeep, Ms. W. Wasana,

7.10.2 Research summary

CONVERSION OF SOLAR ENERGY INTO ELECTRICAL AND CHEMICAL ENERGIES

J. Akilawasan, D. Aluthpatabedi, S. Wasana, K. Wejerathne and J. Bandara

Introduction

Is there a more attractive safer and environment friendly way of producing energy instead of using fossil fuels or nuclear power? The answer is yes and the most suitable method would be solar energy because the amount of energy that the Earth receives from the sun is enormous: 1.75×10^{17} W [1]. The energy which reaches the earth surface can be converted to electricity by photovoltaic devices such as solar cells (Figure 1).

Similarly, it can be converted to chemical energy such as hydrogen by using catalysts (Figure 2). Solar cells are semiconductor devices which have the capacity to absorb light and to deliver portion of energy of the absorbed photons (light) to carriers of electrical current [6]. However conversion of solar with a high efficiency and a lower cost energy remains an important challenge.

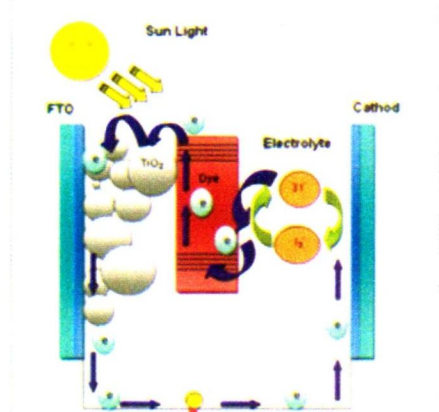


Fig 1: Schematic diagram of a dye sensitized solar cell

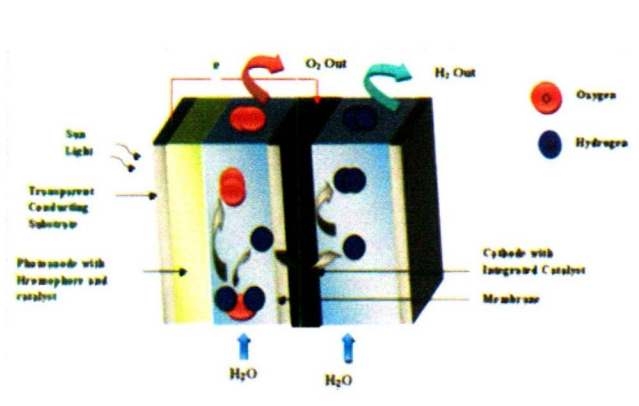


Fig 2: Schematic diagram of a photo electrochemical device

Aim of the project

Synthesis of semiconductor nanomaterials and fabricate tandem solar cells sensitized by UV-Visible-IR for the direct conversion of solar radiation into chemical and electrical energies.

Expected outcome

Sustainable production of energy from renewable source is highly encouraged and one main emphasis in this direction is on solar energy conversion processes delivering heat, electricity and chemical fuel. The project aims at the direct conversion of sunlight into hydrogen fuel and electricity involving dye-sensitized solar cells and other suitable nanocrystalline metal oxide thin films. Photo-produced storable hydrogen using sunlight and water is a renewable fuel with zero emission. H₂ has the potential to meet the requirements as a clean non-fossil fuel in the future, if it can be produced using sunlight and water. If this method becomes economically viable, it will be a leap forward to achieving sustainable use of energy without causing environmental problems.

Results and Relevance to national development

Here we show some of our recent results on dye sensitized solar cells (DSSC) and water splitting reactions. In this investigation, titania nanotubes were introduced into conventional DSSC as an electron conducting medium as they provide straight pathway to electron transport. Titania nanotubes were synthesized via hydrothermal treatment of commercially available TiO₂ powder and deposited onto the conducting substrate FTO (F doped SnO₂) via electrophoretic deposition technique (Figure 3)

Fig 3: SEM image of the hydrothermally synthesized titania nanotubes

Thin film of TiO₂ nanotubes was found to be nearly 10 nm diameter and ~200 nm long. Solar cell fabricated with TiO₂ nanotube and sensitized with dye showed an open circuit voltage (Voc) of 0.75 V and short circuit

current (Jsc) of 5.24 mA/cm² under AM 1.5 G irradiation. The enhancement of the solar cell efficiency is under investigation.

In photochemical energy conversion project our aim was to produce hydrogen using sunlight and water. For this purpose, we prepared different types of nanoparticles that have different types of conductivity (n and p type) and these n (CuO, Copper oxide, Figure 4a) and p (SnO₂ tin oxide, Figure 4b) type nanoparticles were assembled to form n-p type junction (CuO₂-SnO₂ n-p junction) for better photocatalytic activity.

Preliminary results were obtained with the above catalysts and catalytic activity has to be increased and they are under investigation.

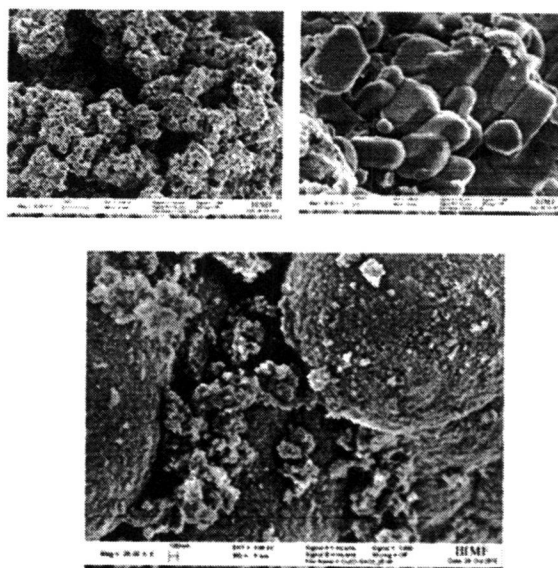


Fig 4: SEM image of (a) CuO, (b) SnO₂ and (c) CuO-SnO₂ nanoparticles.

References

1. O'Regan, B., Gratzel, M., (1991) A low-cost high efficiency solar cell based on dye sensitized colloidal TiO₂ films. *Nature*, 353: 737-740.
2. Tennakone, K., Bandara, J. Bandaranayake, P.K.M., Kumara, G.R.A., Konno, A., (2001) Enhanced efficiency of a dye sensitized solar cell made from MgO-coated nanocrystalline SnO₂. *Jpn. J. Appl. Phys.*, 40, L732-L734
3. Yu, K., Chen, Jungong, (2009) Enhancing solar cell efficiencies through 1-D nanostructures, *nanoscale Res. Lett.*, 4(1): 1-10.
4. Ni, M., Leung, M.K.H., (2007) A review and recent developments in photocatalytic water splitting using TiO₂ for hydrogen production, *Renewable and Sustainable Energy Review*, 11(3): 401-425.

7.11 PLANT BIOLOGY PROJECT

Project leader: Dr. M.C.M. Iqbal, Senior Research Fellow

The research programme of the Plant Biology project concerns climate change and environmental pollution. The projects related to climate change are on the assessment of biomass in the dry zone forests of Sri Lanka and mapping the occurrence of dengue incidence in the Mawanella region.

7.11.1 Social and environmental conditions influencing the spread of the dengue virus

Objectives and progress of the project: The incidence of dengue has increase in the past few years to new geographic and climatic conditions in Sri Lanka. In 2009 the total dengue incidences reported in Sri Lanka was more than 32,000 with over 340 mortalities. The sudden increase of this mosquito borne disease is associated with various socio-economic and environmental factors. This project commenced in October 2009 to study the socio-economic conditions associated with the spread of dengue in the Mawanella area of the Kegalle district. We used Geographical Information System (GIS) to link and update information on environment and climate parameters, hospital reports of dengue patients, and potential breeding locations in urban and semi urban areas of Mawanella. Our purpose was to prepare a Dengue Risk Map to identify areas of high, moderate and low risk and to identify the localities where most attention should be given for control measures. This would enable decision makers at regional levels to strategize and take preventive action to control dengue transmission which is relevant to national development.

Collaborations

Dr. Jagath Gunatilake, Post Graduate Institute of Science, University of Peradeniya Dr. Abdul Haji, Medical Officer in Health, Mawanella Hospital.

Human resource development

Ms. Maduni Madannayake M.Sc (2010) PGIS, University of Peradeniya.

7.11.2 Carbon fixation and dynamics in the dry zone forests of Sri Lanka

Objectives and progress: This project commenced in October 2009. Tropical forests are a major sink for carbon-dioxide. In the context of climate change due to emission of green house gases, it is important to maintain tropical forest cover. Sri Lanka has a forest cover of around 2 million ha of which the dry mixed evergreen forests in the dry zone are 1.09 million ha in extent. While the wet evergreen and montane forests are well studied in the wet zone, the forests in the dry regions, which are more extensive, have received less

attention. Our objective is to determine the carbon fixation potential of the forests in the dry zone of Sri Lanka. This would contribute to estimating the national carbon budget to determine if Sri Lanka is a net emitter or sink of greenhouse gases.

A two hectare permanent sampling plot was established in the Hurulu forest in the North Central province and eight species specific allometric models were developed for biomass estimation. An aboveground carbon data base for five tropical dry (mixed) evergreen forests in Sri Lanka was also completed from published forest inventory data. This project commenced in August 2009 and collaborates with the Forest department of Sri Lanka and the Dept. of Crop Science, Faculty of Agriculture University of Peradeniya.

Collaborations

Mr. A. Sathurusinghe, Deputy Conservator, Dept. of Forestry, Battaramulla. Prof. W.A.J.M. de Costa, Dr. T. Sivanantheverl, Faculty of Agriculture, University of Peradeniya

Human resource development

Mr.M.D.P. Kumarathunge RA , Mr. Manoj Undergraduate, Faculty of Agriculture, University of Peradeniya

7.11.3 Bioremediation of heavy metals

Objectives and progress of the project: This project commenced in October 2009 to determine cost effective measures to remove heavy metals from the environment. Discharge and disposal of waste products contaminated with heavy metals have resulted in the pollution of valuable land and groundwater resources. Pollution by heavy metals is a serious health problem since it is invisible and the effects take a long time to manifest after accumulation in the body. Such toxic metals are lead, chromium, cadmium, mercury and nickel. These enter our environment from industrial wastes and discarded electronic appliances and batteries. Their removal from the environment is difficult requiring expensive engineering and chemical technologies. There are certain plants which can take up these heavy metals from the soil and waterways (Phytoremediation) and store them without any harm to themselves. Passive sequestering of pollutants is possible from aqueous conditions by non-living biomass (bio-sorption). We are investigating such plants, particularly to remove metals from waterways which tend to be polluted by industrial wastes. The dead biomass of the water plant *Cabomba* sp. removes Cr(III) from aqueous media and species of *Fimbristylis* were identified capable of

absorbing nickel and chromium. These plant species are potential candidates for decontamination of waterways and soil for particular heavy metals.

Grant: NRC No. 06-29. Rs.2.46 million

Collaborations

Dr. S.S. Iqbal, Dept. of Chemistry, Open University of Sri Lanka, Nawala

Prof. Namal Priyantha, Dept. of Chemistry, University of Peradeniya

Human resource development

Mr. I. Herath, Dept. of Chemistry, Open University of Sri Lanka, Nawala

Ms. B.R.D.C. Gunasena, Dept. of Science and Technology, Uva Wellessa University, Badulla

Ms. G. Ranaweera, Dept. of Botany, University of Sri Jayewardenapura, Nugegoda.

7.11.4 Research summary

CARBON SEQUESTRATION POTENTIAL OF ABOVE GROUND BIOMASS IN SELECTED DRY EVERGREEN FORESTS IN SRI LANKA

M. D. P. Kumarathunge and M. C. M. Iqbal

Terrestrial vegetation is one of the major sinks for increasing atmospheric carbon dioxide while processing approximately six times as much carbon via photosynthesis and respiration as humans emit from fossil fuel use¹. Approximately 7-10% of the global land area is covered by the tropical forests and it stores 40-50% of the carbon in terrestrial vegetation. Therefore, tropical forests play an important role in the global carbon cycle. The objectives of this paper is to develop an aboveground carbon data base for tropical dry (mixed) evergreen forests in Sri Lanka and to make inference on the carbon sequestration dynamics of these forests.

Estimated aboveground biomasses by this study² for different forests are given in the Table 1. According to the results, above ground biomasses in medium yield forest formations in all five forests were high compared to the low yield and non productive forest formations. Highest biomass density was recorded from the Kantalai forest whereas the lowest was

recorded from Kumbukkan forest. In medium yield forests, tree density is high compared to low and non productive forests. Therefore, the aboveground biomass in medium yield forests is high compared to low and non productive type. Comparison of the size class and aboveground biomass shows evidence of reduction in biomass in higher size classes. Low tree density and logging of larger trees in excess of re-growth could be possible reasons for this Carbon content in aboveground biomass was calculated by assuming the carbon content is 50% of the amount of total above ground biomass. According to our results the highest aboveground carbon storage is in the Kanthalai forest and the lowest was from the Kumbukkan forest (Table 1). In Kanthalai forest, tree density of all diameter classes is significantly high compared to other forests. This could be the reason for higher carbon density in that forest. Carbon sequestration potential of all forests is closely related to the tree size class. The main size classes that had a high potential in carbon sequestration are from small to medium tree sizes at 10-20 cm up to 40-50 cm.

Table 1. Aboveground biomass and carbon estimates for different forests. Values in parenthesis are aboveground carbon stocks estimated as 50% of the total aboveground biomass.

(NA: The category not existing in the forest)

Yield category	Aboveground biomass/carbon content (Mg ha ⁻¹)				
	Hurulu	Kumbukkan	Pallekelle	Kantalai	Madhu
Medium yield	123.6 (61.8)	75.6 (37.8)	79.2 (39.6)	146.9 (73.5)	NA
Low yield	85.4 (42.7)	59.4 (29.7)	95.8 (47.9)	112.3 (56.2)	83.7 (41.8)
Non productive	55.6 (27.8)	NA	78.2 (39.1)	NA	80.8 (40.4)
Average	88.2±34.1 (44.1±17)	67.5±11.5 33.7±5.7	98.13±9.9 49±5	129.6±24.5 64.8±12.2	82.3±2.6 41±0.9

References

1. Lewis, S.L. *et al* (2009). Increasing carbon storage in intact African tropical forests. *Nature*. 457: 1003-1006
2. Kumarathunge, M.D.P. and Iqbal, M.C.M. (2009).

Biomass estimation in some dry zone forests in Sri Lanka from forest inventory data. *Proceedings of the fourteenth International Forestry and Environmental Science Symposium, 2009*. University of Sri Jayawardenapura. Sri Lanka. pp. 01.

7.11.5 Research summary

REMOVAL OF CHROMIUM FROM WATER BY THE WATER PLANT *CABOMBA SPP.*

P.K.D. Chathuranga and M.C.M. Iqbal

Introduction

Discharge and disposal of waste products contaminated with heavy metals such as chromium, lead, nickel, cadmium, etc. into water streams have resulted in the pollution of our aquatic water-ways. Since heavy metals are toxic to life, their removal from the environment is important. Although several chemical and physical methods are available for their removal, their implementation is restricted due to high cost and complexity. The concept of biosorption¹ was introduced as an alternative cost effective simple technique where non-living biological materials such as dead aquatic plants, saw dust, tea waste, fruit peels, etc. are used to remove pollutants.

Aims and Objectives

The non living biomass of *Cabomba spp.* (horse tail), a fresh water aquatic plant (Fig.1), was studied to investigate its potential to remove chromium in solution.

Fig. 1. *Cabomba spp***Results**

A chromium solution of concentration 5.0 mg/L^{-1} was mixed thoroughly with the biosorbent (200 mg of powdered dry Cabomba) and showed a 46% removal within a very short period of nine minutes (Fig.2). This was achieved at pH 5.0 which is the acidity of most of the effluents.

It was also found that the removal capacity depends on the amount of the plant material. The efficiency of chromium removal also depends on the degree of contact between the biosorbent and chromium solution and the particle size of the plant material. The removal percentage of chromium was low at more acidic and more basic pH conditions with an optimum pH of 5.0 (Fig. 3).

The kinetic studies showed that a single layer of the metal formed on the plant material at low concentrations of heavy metals, whereas many layers formed at higher concentrations (isothermal study)². According to our results the use of *Cabomba spp.* is a potential solution for waste water treatment. Since it is

a very cheap and simple technique, it can be easily adopted to industries in Sri Lanka to clean up their chromium contaminated effluents.

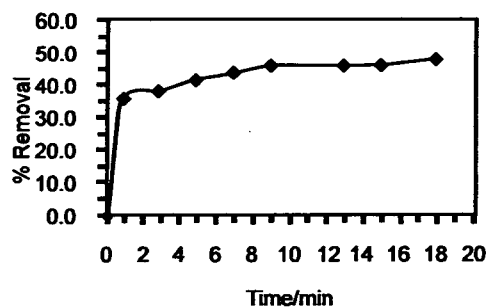
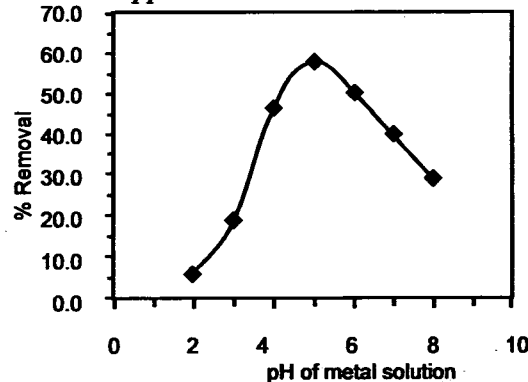
Fig. 2. Percentage removal of Chromium by *Cabomba spp*

Fig. 3. Percentage remove of Chromium with pH of solution.

References

1. B. Volesky, Sorption and biosorption BV Sorbex Inc., Montreal - St. Lambert, Quebec, Canada, 2003.
2. Chathuranga P.K.D., Priyantha N., Iqbal S.S., Iqbal M.C.M., Biosorption of Cr(III) from aqueous solutions by *Cabomba spp.* -pH effect and Isothermal study-. In 66th Annual Session of the SLAAS, 2010.

7.11.6 Research summary

A GIS APPROACH TO GENERATING A DENGUE RISK MAP

M.P Madanayake¹ and M.C.M Iqbal

Introduction

The incidence and spread of dengue is associated with different factors unrelated to each other such as socio-economic conditions socio, cultural practices environmental factors and change in climate. To integrate these different aspects and acquire a holistic picture, Geographic Information System (GIS) and remote sensing are valuable tools which enable to link and update information between the different factors and the reported number of dengue incidents with their breeding locations. The preparation of a dengue risk map for a particular area is a useful tool for decision makers to develop strategies and investment for disease control. The objective of this study is to identify high, moderate and low risk areas of vector breeding and to develop a Dengue Risk Map (DRM) as a tool for decision makers to respond, strategize and create preventive action plans to control dengue transmission with the help of GIS technology with the intention of fulfilling a social obligation. Similar studies have been done to identify dengue risk areas in Rajasthan, India¹ and in Jaffna district to identify malaria risk².



Figure 1: Collecting data on vector breeding

The geographic locations of patients, vector breeding places, and socio-economic and climatic factors were collected using a Global Positioning System (GPS). All the data were integrated and analyzed using GIS software (Figure 2).

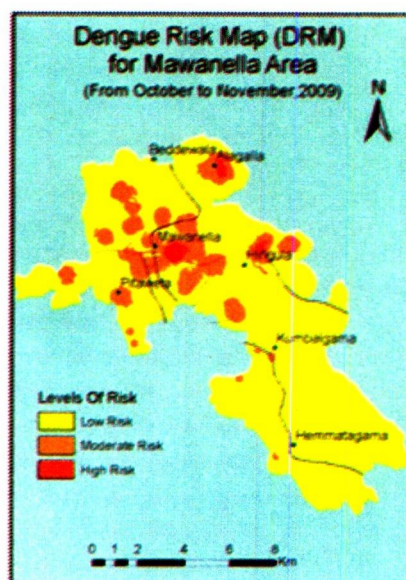


Figure 2: Dengue Risk Map

The ability of Risk Maps to identify the degree of risk through environmental and socio-economic factors associated with disease vectors makes it increasingly essential in the surveillance infectious and vector borne diseases³. Our study to identified high risk areas in the Mawanella MOH area and this information is useful for the health sector to initiate immediate action to combat the disease.

References

1. Bohra, A. and Andrianasolo, H., (2001). Application of GIS in modeling of dengue risk based on socio cultural data in Jalor, Rajasthan in India. *Dengue Bulletin*. 25, 92 – 102.
2. Kannathasan, S., Antonyrajan, A.G., Karunaweera, N.D., Anno, S, Surendran, S.N., (2009). Identification of potential malaria risk areas of the Jaffna district of northern Sri Lanka: A GIS approach. *Journal of National Science Foundation of Sri Lanka*. 37(3), 223-225.
3. Madanayake, M.P., Gunetilake, J., Haji, A., Iqbal, M. C. M., A GIS Approach to Generating a Dengue Risk Map. *Map-Asia 2010 Conference*. 26th – 28th July 2010, Kuala Lumpur, Malaysi

7.11.7 Research summary

A SUSTAINABLE ECOLOGICAL APPROACH TO MANAGE USSANGODA SERPENTINE SITE

B. R Randunuge and M. C. M. Iqbal

Introduction

The Ussangoda Serpentine site is a source of curiosity among visitors due to its unusual red colour of the soil (Fig. 1), its rich historical and mythological background, and natural existence. However, the deposition of magnesium and nickel rich serpentine minerals is the inherent secret of this unusual plains with its stunted vegetation and it is a popular recreational site for both local and foreign visitors.



Figure 1. The plains with characteristic red soil

It is a plateau located between the sea and the Tangalle-Ambalanthota road with large expanse of a plain and the highest point the Ussangoda hill. The stunted vegetation on the plains of Ussangoda is sharply demarcated from the adjacent non-serpentine by large shrubs and trees. Patches of shrubs occur on the plains creating a patch-work of micro habitats due to the different metal composition of the soil (Ni, Fe, Mg, Ca etc.) and other physical properties. The sea-horse shaped site is even visible from satellites (Fig. 2). Our study on the Ussangoda serpentine site is to understand the ecological significance of this land and to identify the plant species that have evolved biological mechanisms to accumulate metals.

This forms the basis for using plants to develop environmental friendly techniques for extraction of heavy metals from contaminated soils using plants.



Figure 2. Satellite image of Ussangoda serpentine site from Google Earth

In association with the Man and Biosphere committee of the National Science Foundation of Sri Lanka these studies would contribute to proposing a Geopark model for Ussangoda serpentine site as a socio-economically and environmentally sustainable system for the local community to conserve this ecosystem and contribute to national development.

Of a total of 26 plant families, nine families with 12 species occur on the serpentine plains and the rest occur as patches of shrubs. The species on the plains are dwarf, stunted with small leaves, thick stems and an extensive root system. Most of the plants on the plains showed metal hyper accumulation ability (Table 1).

Table. Nickel hyper accumulators identified from Ussangoda Plain

Species	Ni($\mu\text{g/g}$)
<i>Euphorbia spp.</i>	1208.80
<i>Evolvulus alsinoides</i>	1016.25
<i>Vernonia cinerea</i>	1007.80
<i>Cassia kleinii</i>	945.80
<i>Desmodium spp.</i>	914.09
<i>Hybanthus enneaspermus</i>	757.15
<i>Fribristylis falcata</i>	682.60

The total Ni concentration of serpentine soil is 2740 $\mu\text{g/g}$ and the average plant availability is 277.72 $\mu\text{g/g}$. A defining characteristic of a serpentine soil is the ratio of calcium to magnesium (Ca:Mg) in the soil which is less than 0.6, while in a normal non-serpentine soil it is higher than 6. The Ca:Mg ratio of Ussangoda serpentine soil was 0.6 to 1.66. This low Ca:Mg ratio is characteristic for serpentine soils² since they result from weathering of serpentinite and other ultramafic rocks having high ferromagnesian minerals³. The availability of nutrients for plant growth is low, the pH is acidic and organic matter content is also low. The physical structure of the soil does not retain soil moisture and is unsuitable for plant growth. According to our results the chemical properties of the serpentine soil (CEC and Ca:Mg) is strongly correlated with the distribution of Mg and Ni in the soil and it is the ultimate determinant of the soil characteristics and consequently of plant life.

The flora in Ussangoda is unique having evolved over thousands of years to adapt themselves to this unusually harsh environment. This restricted habitat with their isolated communities of plant species contributes to our biodiversity and is highly vulnerable to destruction from visitors who are unaware of their significance.

With the significant value of this site in terms of its archeological, historical and ecological aspects, it is necessary to implement conservation measures in a

sustainable way making it a part of the socio-economic and cultural development of the local community and thereby conserve the site for posterity.

References

1. Brady KU et al. 2005. Evolutionary ecology of plant adaptation to serpentine soils. *Annu. Rev. Ecol. Syst.* 36:243-266
2. Brooks RR 1987. In *Serpentine and its vegetation*, ed. TR Dudley. Portland OR: Dioscorides. 454 pp.
3. Kruckerberg AR 2002. The influence of lithology on plant life. In: *Geology and Plant life: The effect of landforms and rock type on plants*, pp. 160-181. Seattle, London: Univ. Wash. Press. 362pp.

7.12 PRIMATE BIOLOGY

Project Leader: Dr. Wolfgang Dittus, Honorary Senior Visiting Scientist

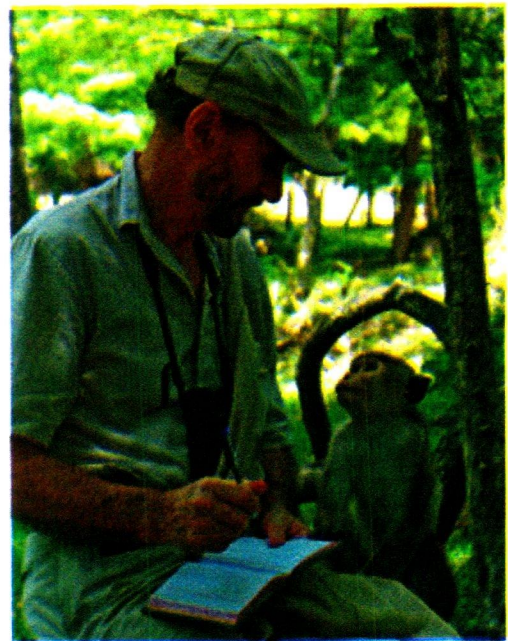
This project concerns observational studies of monkeys (primates) in their natural forest habitat at Polonnaruwa. The overall aim of the project is to establish new knowledge concerning the biological foundations for social behaviour in non-human primates (and by inference, in man). Behaviour is a complex multifaceted phenomenon and our aim has interdisciplinary ramifications. Hence, past research and publications have addressed the interrelationships among social organization, matrilineal kinship, ecology, genetic diversity and environmental change. In particular we are interested in measuring the effects of such variables on demography or Darwinian fitness (survival, reproduction, and migration). 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. Such data are used to test current socio-biological and evolutionary hypotheses and have broad scientific relevance.

In practice, to investigate the phenomenon of social evolution we have identified more than four thousand macaque individuals (living plus dead), distributed among 34 different social groups at our study site. For each macaque, we have traced its behavioural, genealogical, ecological and demographic history. In addition, we have recently completed the patrilineal identification of about 1,500 macaques. Our methods are similar to those of actuaries, linking variables of behaviour to those of survival. To this end we require large samples over extended periods of time to assure statistical soundness.

Although we had established the link between behaviour and fitness it was not clear by which physiological and similar mechanisms behaviour affected death rates. 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, blood chemistry, hormone levels) in relation to behaviour and vital statistics. Different aspects of physiology and disease have been more intensively investigated in the primates at Polonnaruwa particularly in collaboration with of the Faculty of Veterinary Medicine, University of Peradeniya.

Our research has practical applications relevant to Sri Lanka's national development. For example, we have shown the important relation between human and primate diseases, such as dengue fever, toxoplasmosis, cryptosporidium and other infectious diseases. At another level we also are proactive in nature conservation and in outreach educational programs to local communities and assist in mitigating the conflict between humans and monkeys. Finally, our research has been broadcast internationally through high quality documentary films. Our films have given Sri Lanka a positive image in the international political and economic arenas, and have attracted visitors to the country.



Collaborators:

Prof. RPV Jayanthe Rajapakse, Professor of Parasitology and Head of the Department of Pathobiology, University of Peradeniya, Peradeniya.

Dr. Ashoka Dangolla, Faculty of Veterinary Medicine and Animal Health, University of Peradeniya.

Prof. Peter Nuernberg, Cologne Center for Genomics CCG, University of Cologne, Germany Kerstin Becker (Graduate student), Cologne Center for Genomics CCG, University of Cologne, Germany Rashika Kumarasingha (Graduate student), Department of Pathobiology, University of Peradeniya, Peradeniya. Amanda Schenk, Fulbright Scholar, Sri Lanka-USA

Dissemination of Science

Documentary Film Production: 2009 -2010. Our dissemination of science impact was global. My team of assistants at Polonnaruwa and I were key to the production (by NHNZ) of a series of 14 half-hour films about monkey behaviour. The series, entitled "Dark

Days in Monkey City," is being broadcast internationally on the Animal Planet, Discovery Channel. We use our scientific discoveries at Polonnaruwa to educate and inspire people world-wide towards nature conservation.

Research and science exposure for younger generation

Three graduate students (U. Peradeniya, U. Cologne, and Fulbright) participated in our research in 2009-2010 as indicated above. Our greater impact (second to our international TV documentaries), however, was in promoting nature education among schools at Polonnaruwa. We delivered 11 programs to schools in 2010, and served as the official resource for the "practicals" of 120 Advanced Level Biology students (Royal College, Polonnaruwa).

Conservation Actions

In 2010 we executed 38 conservation action events.

7.13 THEORETICAL AND COMPUTATIONAL SCIENCES RESEARCH

Project leader: Prof. Asiri Nanayakkara, Research Professor

7.13.1 Sonoluminescence Research Project

Sonoluminescence is created by the mysterious conversion of acoustic energy into pulses of light. Single Bubble Sonoluminescence (SBSL) is observed when the interaction between a diffuse sound wave and a small isolated bubble concentrates vibrational energy by 12 orders of magnitude to produce flashes of light in the UV range as the bubble collapses. Bubble collapse usually produces about 500,000 photons. Temperature inside the bubble when it emits light is estimated to be greater than 15,000K which is above the surface temperature of the Sun (in some systems the temperature has been estimated around one Million Kelvin).

SBSL has been, and continues to be, the subject of considerable experimental and theoretical research since light emission mechanism has not been fully understood yet. Also SBSL has attracted many scientists' attention due to its potential in producing unlimited clean energy via cold fusion. The light emitting mechanism in SBSL is one of the unsolved problems in Physics at the moment.

Objectives and progress of the project: Aim of this project to understand the mechanism which produces light in SBSL. The project consists of three components: Computational investigations, Experimental investigations and Theoretical investigations.

Computational methods

In order to understand what is going on inside the bubble when it emits light, we use computers to simulate physical situation inside the bubble when it emits light. Also using computational chemistry software, we study sonochemical reactions which may take place inside the bubble and investigate how they may affect the overall behavior of the bubble.

Experimental methods

We investigate various aspects of SBSL experimentally. We also investigate SBSL under various physical conditions to help developing a theory to explain all the properties and the mechanism of SBSL.

Theoretical methods

Detail quantum mechanical investigation is carried out to understand light emission phenomenon in

SBSL.

In this recently started (in 2010) project, we have developed software to simulate SBSL bubble on a single workstation. New computational techniques are being developed to improve the performance of the software and to run it on workstation clusters having multicore processors.

Human resource development

Hasara Samarasinghe BSc (Special- Final year research project) in Chemistry
University of Colombo

Shshika Wijesinghe BSc (Special- Final year research project) in Chemistry
University of Colombo

7.13.2 Quantum Mechanics and Quantum Chaos Project

In this project our aim is to understand the behavior of multidimensional systems in the semiclassical limit. (i.e. limit between quantum mechanics and classical mechanics) and classical, semiclassical and quantum mechanical behavior of both Hermitian and non-Hermitian Hamiltonian systems.

In recent years, the manifestation of chaos in quantum mechanics has 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.

Results

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.

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

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.

Distribution of zeros of quantum wave functions and second differences of energy at avoided crossings were investigated. We developed new approximation and numerical methods for locating zeros of wave functions. Hermitian systems have been studied to establish a connection between classical chaos and behavior of quantum eigen states at avoided crossings.

Non-PT symmetric systems were studied with non-perturbative action angle theoretical methods. Semiclassical Lie transformation methods were modified for complex non-Hermitian systems.

Complex symplectic structure of phase space of non-Hermitian Hamiltonian systems were studied and for several systems Birkhoff normal forms were derived and reality of constants of motion of multidimensional systems was studied with Birkhoff normal forms and Lie Transform methods.

Periodic and quasiperiodic nature of classical trajectories of 2D non-Hermitian Hamiltonian systems was investigated using classical perturbation theory. Approximate expressions for classical frequencies were found in analytic form in terms of the second constant of motion. It was found that the classical trajectories are quasiperiodic if both quantum spectra and the second constant of motion are real.

This project has produced 25 research papers and 3 research communications since its inception in 2000.

7.14 IMPROVEMENT OF DRINKING WATER QUALITY

Project Leader: J.P.Padmasiri , Visiting Scientist

Research Team – Engineer, W.M.Jayawardhane – Volunteer, Namal Athukorala – Senior technical officer, M.T. de Silva - Volunteer

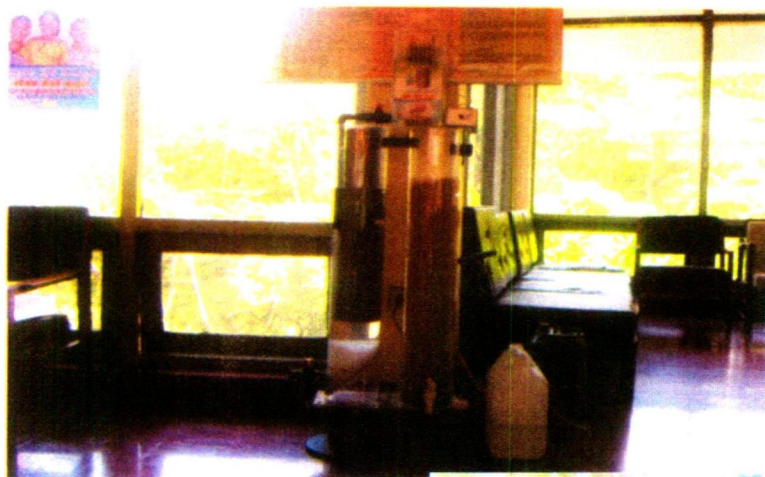
Research Description –

Electro -Coagulation is a 100 year old technology, used very often in the waste water industry. It is simple and could be designed and fabricated in Sri Lanka. It is less costly than the Reverse Osmosis methodology. In this context, our investigations have been focused on designing and fabricating an “Electro Coagulation Unit” to reduce excess hardness and fluoride in drinking water. Research and development work started in February 2010. A house hold unit with the capacity of processing 5 liters of water at a time (50 liters/d) has been introduced to the market in October 2010 by Spectra Industries, Kurunegala. In addition, a 100 l/hour Electro Coagulation unit has been commissioned in Asokamadagama, Pemaduwa in the Anuradhapura District in August 2010. The

fluoride content of 5.2 mg/l and total hardness of 180 mg/l CaCO_3 of water in Asokamalagama have been reduced to 1.1 mg/l fluoride and of 80 mg/l CaCO_3 respectively. The efficiency of removal of fluoride is 80–90 % and that of hardness is 50–60 %.

Collaborations –

Link Natural Products (Pvt) Ltd, Kapugoda
Atlas Machine Components (Pvt) Ltd – Dompe
National Water Supply and Drainage Board,
Spectra Industries Lanka (Pvt) Ltd, Kurunegala.



Electro –Coagulation unit at Asokamalagama, Pemaduwa

8. COLLABORATIVE AND CONSULTATIVE DIVISION (CCD)

Co-ordinator: Prof. S.A. Kulasooriya, Visiting Research Professor

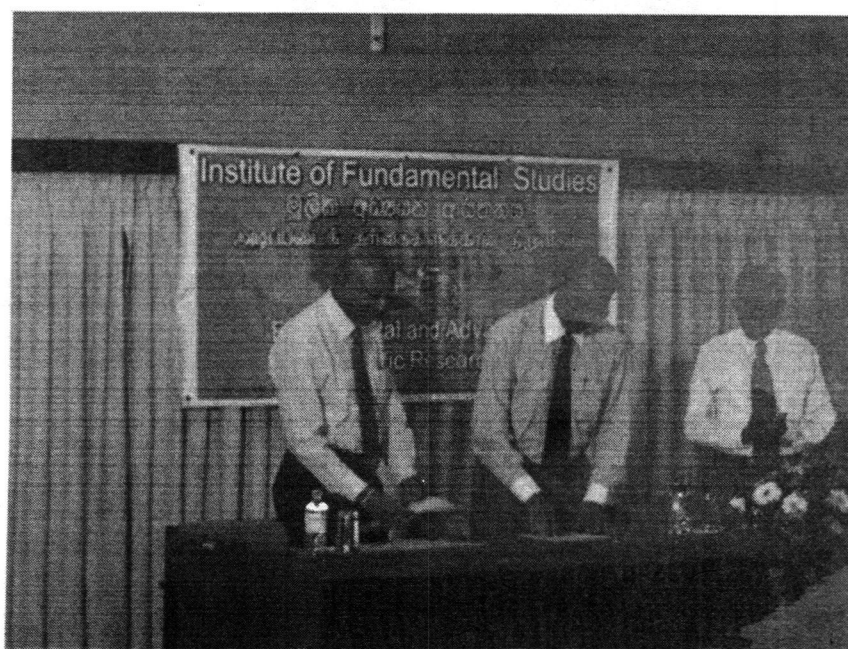
The collaborative and consultative division of the IFS was established to direct basic research towards national development. The CCD will link government organizations, NGOs and private sector organizations with the IFS to conduct research for national and economic development of the country.

The CCD was established to a) conduct basic research in collaboration with outside organizations, b) transfer science and technology for national development, c) offer consultation services and d) undertake commissioned research that would impact positively on national development.

Organizations involved with the CCD include Universities, Higher Educational Institutes, Research Institutes, Non-Governmental Organizations (NGOs), Community Based Organizations (CBOs) as well as Corporate and Private sector organizations that are registered with the Government of Sri Lanka. The commissioned and collaborative research projects established so far are given in Table 1.

TABLE 1
COMMISSIONED RESEARCH

Name of the Applicant	IFS scientists/s involved	Title of Project/s
Natures Beauty Creations Ltd. (NBC)	Prof. S.A. Kulasooriya	Commercial application of Murunga
National Water Supply and Drainage Board	Mr. J.P. Padmasiri	Evaluation of Trihalomethane (THM) formation possibility in treated water supply in central province
	Prof. S.A. Kulasooriya	
	Dr. D.N. Magana-Arachchi	



Signing agreement with NBC

TABLE 2
COLLABORATIVE RESEARCH

NAME OF THE APPLICANT	IFS SCIENTIST/S INVOLVED	TITLE OF PROJECT/S
Dr. S. Yatigammana Dept. of Zoology University of Peradeniya	Prof. S. A. Kulasooriya Dr. D. Magana-Arachchi Mr. J.P. Padmasiri	Studies on planktonic organisms- their effects on water quality of freshwater reservoirs in Sri Lanka
Dr. T. Abeysekara Teaching Hos[ital. Kandy	Dr. D. Magana-Arachchi	Chronic Kidney Diseases of unknown Aetiology (CKDu); is it Cyano to xins?
Dr. R.M.D. Madegedara Teaching Hospital, Kandy	Dr. D. Magana-Arachchi	Detection of Non-tuberculosis Mycobacteria (NTM) with microbiological and molecular typing methods
Mr. H.A. Ariyawansa PGIS, <i>University of Peradeniya</i>	Prof. G. Seneviratne	Deniyaya tea die-back problem
Dr. S.P. Nissanka Faculty of Agriculture University of Peradeniya	Prof. G. Seneviratne	Assess methane emission from rice fields
Director/CEO Finlays Tea estates Lanka (Pvt.) Ltd	Dr. Renuka Ratnayake	Soil C sequestration in forest/tea plantations
National Water Supply and Drainage Board	Mr. J.P. Padmasiri Prof. S.A. Kulasooria Dr. D. N. Magana-Arachchi	Water quality monitoring North Central Province and surveillance for algal to xins
National Water Supply and Drainage Board	Mr. J.P. Padmasiri	Removal of hardness and fluoride in ground water by electro-coagulation in North Central Province
National Water Supply and Drainage Board	Mr. J.P. Padmasiri	Removal of alage from irrigation tank water by electro-coagulation in North Central Province

9. AWARDS, RECOGNITIONS & PATENTS 2009-2010

Prof. M. A. K. L. Dissanayake received the "CVCD Outstanding Senior Researcher Award" for the Physical Sciences from H.E. the President on 16th December 2010. These awardees are selected by the Committee of Vice Chancellors and Directors of the University Grants Commission."

Prof. C. B. Dissanayake Doctor of Science (*Honoris causa*) degree (2009) awarded by the Sabaragamuwa University of Sri Lanka

Prof. C. B. Dissanayake- Emertius Professor, Faculty of Science, University of Peradeniya.

Prof. N.S. Kumar - Emertius Professor, Faculty of Science, University of Peradeniya

Prof. S.A. Kulasooriya- Emertius Professor, Faculty of Science, University of Peradeniya

Dr. Meththika Vithanage, Mr. Lakmal Jayarathne of the IFS and, Prof. Ken Kawamoto and Mr. Shaphal Subedi at Saitama University, Japan received the Best Presentation Award for their research paper on "Assessment of Water Repellency of Model Sands Mixed with Oleic Acid" at the 12th International Summer Symposium of Japanese Society of Civil Engineers.

Dr. Meththika Vithanage received the Best Graduate Scientist on Natural Hazards Award , 2009 by the Natural Hazards Focus Group, American Geophysical Union in 15th December, 2009 at San Francisco, USA

Ms Zahmeeth Sakka, Research Assistant, Artificial Intelligence and Applied electronics Research Unit, received the best student paper award (2010) in the area of *Intelligent Machines and Man-machine Co-existence* at the 5th International Conference on International conference on Information and Automation for Sustainability (sponsored by IES and IEEE member Societies.)

Ms. Maduni Madanayake, Best presentation at the MapAsia Conference 26 – 28 July 2010 in Malaysia on 'GIS approach to generate a Dengue Risk map'.

Presidential Awards for Scientific Research 2003-2006

The following researchers received Presidential awards 2010 for their scientific research work conducted at IFS from year 2003 to 2006.

Arundathie BGS	Jayasinghearachchi	HSPradeep UW
Balasooriya	BAISJayasooriyaChompika P	Premalal EVA
BandaraJayasundera MS	Jayaweera P Viraj V	Ramanayake SM Shantha D
Bandara RGSJ	KathirarachchiHeasha A	Rupasinghe GK
Bandaranayake KM	Kehelpannala KVV	Senadeera GK Rohan
Priyangika	Kottegoda Iresha RM	Senevirathne MKI
Dharmaratne H Ranjith	Kumarihamy BMM	Seneviratne Gamini
Dias HV Rasika	Kuruppu SS	Seneviratne Wasana
Dissanayake L	Makehelwala M	Silva E Ivan
Dittus WPJ	Meemaduma VN	Sirimanne PM
Divarathne CM	Moorthy SAV	Tennakone Kirthi
Ellepola SW	Nanayakkara A Asiri	Vithanage M
Fernando Gayanath W	Nanayakkara SD	Wanniarachchi WA Vajira R
Gunaratne Gamunu H	Padmini WC	Weerasinghe HC
Herath HMT Bandara	Pathirathne WMT	Weerasooriya SV Rohan
Iqbal M Cassim M	Perera S	Weerawardene TE
Jayasekera WG	Perera VP Susira	Weligamuwa PMGMP
Jayasinghe ULB	Pitigala PKDDP	Wickramarachchi Priyangika
Wijayantha KGU	Wijesekara HKDK	Wijewardhana
Wijayasinghe A	Wijesekara Kolitha	Yasawardena

PATENTS (2009 onwards)

1. Portuguese Patent Application No. 104634, Portugal

Patent in Method for perpertrating electrochromic inks, Patent applied by Y-Dreams –Portugal 2009, Madan Parque - Sul, Quinta da Torre, 2825-149 CAPARICA. Portugal By Claudia B. da Costa, G.K.Rohan Senadeera, Elvira Maria Correia Fortunato and Ines Domingues da Silva Henriques.

10. SCIENCE DISSEMINATION UNIT (SDU)

The objectives of the Science Dissemination Unit (SDU) are to bring together leading experts in different areas of science, foster the exchange of technical and scientific information by providing a forum for the scientific community, and to promote public understanding of science.

These objectives were achieved using different strategies, science and Technology was promoted by organizing workshops, conferences, exhibitions, public lectures, special lectures and research meetings. Awareness and educational programs for students, such as the School Science Programme (SSP) and other educational lectures were also arranged. Educational visits were organized for postgraduate students, undergraduate students, teachers and school children.

A Workshop on “Bioassays for Natural Products Research” organized by the Natural Products Chemistry Research group in collaboration with the SDU of the IFS was held during 25th-26th of March, 2010.

A workshop to improve communication skills “Improving the Science Communication Skills of Researchers” was conducted during 17–18 August, 2010.

Science communication in non-technical language to the general public is of great importance today. The SDU organized a workshop for researchers at the IFS to improve their communication skills. Dr. Jayantha Wattevidanage and Mr. Thusitha Malalasekara, Advisory board members of the science popularization division of the National Science Foundation (NSF) were the trainers during this workshop.

Three Electronic Workshops for O/L teachers were conducted from 14 – 21, September 2010 by Mr. D M Wijethunga. Three hundred teachers actively participated in this program.

Three workshop on Nanoscience for O/L teachers were conducted in Tamil (October 11 2010), Sinhala (October 18th 2010) and English (2010). Three hundred teachers participated in the program.

Exhibitions

EDUCATIONAL & DEVELOPMENT “DAYATA KIRULA” on 4–11 February, 2010 at Pallekale,

“VIDATHA” National Science Day Exhibition was held on 3 - 4, November, 2010 at Kandy. Two lectures on “To a new world through Nanotechnology” and “Nanoscience for a better future” were conducted by Dr. Kumari Tilakaratne, Coordinator/SDU at the exhibition.

Public Lectures

Eight public lectures were held during this year.

- | | |
|------------|---|
| 06.01.2010 | “Secondary Metabolites of Marine Cyanobacteria”
<i>Dr. Sarath P Gunasekara</i> , Research Chemist, Smithsonian Marine Station, Fort Pierce, Florida. |
| 10.03.2010 | “Life in the Cosmos”

<i>Prof. Nalin Chandra Wickramasinghe</i> , Professor in Astrobiology and Director of the Cardiff Centre for Astrobiology, Cardiff University Emeritus Professor of Applied Mathematics and Astronomy, Cardiff University, Honorary Professor, University of Glamorgan |
| 26.04.2010 | “Accreditations, Good Laboratory Practice and ISO's, and Providing Services to Industry”. <i>Mr. B.S.P. Mendis</i> , Director /CEO Sri Lanka Accreditation Board |
| 22.06.2010 | “Studies on Climate, impacts and adaptation for Sri Lanka: looking back and ahead on work at the IFS, EI and FECT”.
<i>Dr. L.Zubair</i> (Principal Scientist, Foundation for Environment, Climate and Technology (FECT), Digana, Sri Lanka). |

- 25.08.2010 **“Contaminated water affects Health”**
Prof. Sunil J.Wimalawansa, (University of Medicine and Dentistry, New Jersey)
- 27.10.2010 **“Problems with monkeys': myths and solutions”**
Dr. Wolfgang Dittus (Senior Visiting Scientist, IFS)
- 10.11.2010 **“Designing a fish assessment programme for High Pesticide use Agricultural areas in Sri Lanka”**
Mr. J. A.Sumith, Canadian Rivers Institute and Department of Biology, University of New Brunswick, Canada Registrar of Pesticides, Department of Agriculture, Sri Lanka
- 01.12.2010 **“An introduction to unconventional Geothermal Energy: the Australian experience”**
Dr. Luke Mortimer (Senior Consultant, Hot Dry Rocks Pty. Ltd/Australia)

Research Colloquia

- 07.04.2010 **“Science & Biology”** *Dr. M. C. M.Iqbal, (Senior Research Fellow/IFS)*
- 23.06.2010 **“Strategies to avoid being eaten: Mimicry in spiders and other animals”**
Dr. Suresh P. Benjamin (Senior Research Fellow, IFS)
- 30.06.2010 **“Brain Computer Interface”** *Prof. Asiri Nanayakkara (Research Professor, IFS)*

Research meetings – conducted by Research Assistants at the IFS

- 21.04.2010 **Production of Cellulosic Biofuels from Invasive weeds in Sri Lanka with aid of Bio-films microorganisms.** *Ms. Damitha Gunatilake.*
- 02.06.2010 **“A Comparative survey on phytoplankton and zooplankton in Sri Lanka Reservoirs”.**
Ms. B.Perera.
- 16.06.2010 **“Diversity of Pseudoscorpion Fauna of Sri Lanka”** *Mr. S.Batuwita*
- 19.08.2010 **“Search for bioactive secondary metabolites from fungi”** *Ms. D. A.Siriwardhana*
- 01.09.2010 **“Bioactive secondary metabolites from Lovi and Tea”** *Ms. Achala Alakolanga*

Awareness and Educational Programmes for Students

School Science Programme (SSP) 10 – 13 August, 2010

The school science programme (SSP) is conducted annually by the SDU for the dissemination of science among the younger generation. The aim of this activity is to expose young students to frontiers of science and to indicate how science is practised. An added advantage is that this program enables students to meet and mix with students from different ethnic, economic and cultural backgrounds in an informal atmosphere

The SSP has been conducted as a continuous series from 1987 and a total of 2427 students have participated up to now. This year there one hundred and seventy students for the School Science Programme (SSP-2010) from schools located in all areas of the country. Students who excelled at the GCE (Ordinary Level) examination in 2009 participated in this activity. An educational visit to the University of Peradeniya was included this year.

10 August 2010

An inexpensive, experimental approach to learning Aerodynamics

Mr. Tilak Dissanayake, MD/Architect, Ants Global (Pvt) LTD

Mimicry in Spiders & other animals

Dr. Suresh Benjamin, Senior Research Fellow, IFS

11 August 2010

Brain Computer Interface

Prof. Asiri Nanayakkara, IFS

Science & Science Communication

Dr. Kumari Tilakaratne, IFS

Global Warming IFS

Dr. M. C. M. Iqbal, Senior Research Fellow,

12 August 2010

Gene Technology

Dr. Dammika Magana-Arachchi, Research Fellow, IFS

Science & Mathematics for a comfortable life

Dr. Jayalath Edirisinghe, Faculty of Engineering

University of Peradeniya

Educational Lectures

Two lectures conducted by Dr. Kumari Tilakaratne, Coordinator, SDU, were

“Nanoscience & Nanotechnology” 11 November 2010

For A/L students and teachers at the “SCIENCE DAY” of Rahula College, Katugastota.

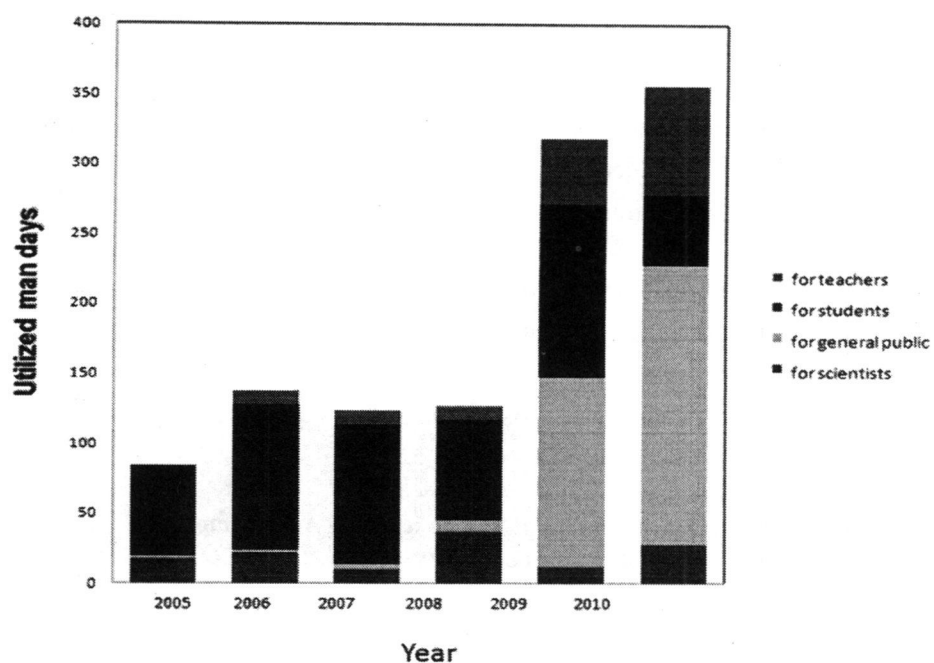
“Nanotechnology for a better future” 23 November 2010

An educational lecture for students and teachers at the workshop organized by the “Vidatha Center- Hanguranketh

Educational visits

Laboratory visits were organized for school children, teachers, undergraduate and students from other institutions. A special lecture on IFS and its activities was held to enable these students to gain a better understanding of IFS activities.

18.02.2010	Teachers and students from MahaDolapihilla M V Kandy,
12.03.2010	Undergraduates from Rajarata University, Mihintale
07.12.2010	Teachers and students from All Saints' College, Galle



Dissemination of scientific knowledge by Science Dissemination unit

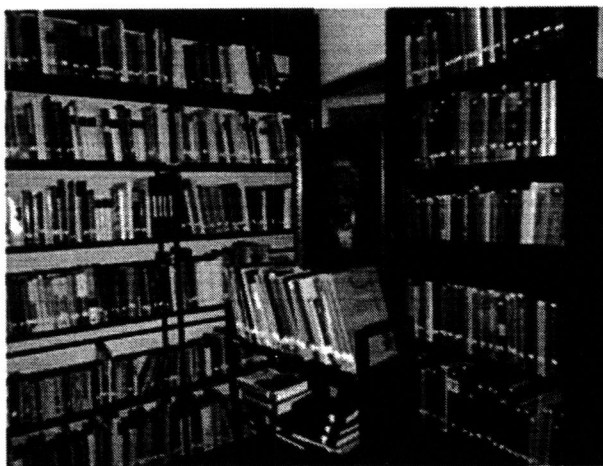
11. LIBRARY

The IFS library was established in 1985 with a small collection of books and journals donated by Prof. Cyril Ponnampereuma, well-wishers and the Asia Foundation. Since then it now has a modest collection of over 5800 books covering the life, physical and mathematical sciences as well as the philosophy and history of science. The fundamental text books, monographs and edited volumes in the library serve as sources of references to the research staff, postgraduate students and visitors to the Institute. Among our oldest collection are two volumes on Leonardo Da Vinci published in 1898.

Books are now continually added to the library from recommendation of the project staff. This year also saw the adding of over 270 valuable books from the personal collections of the late Professor Stuiver and Prof. A. Kovoov donated by Mrs. Stuiver and Mrs. Kovoov respectively. To accommodate the new arrivals and provide access to archived materials the library has expanded its floor space by 140 square meters this year.

The mission of the IFS library is to assist research staff and students to acquire the relevant literature for their research. This is facilitated by acquisition of materials through inter-library loans, organization of the existing books and journals, document delivery, resource sharing, information alert services and sourcing web based electronic journals and articles.

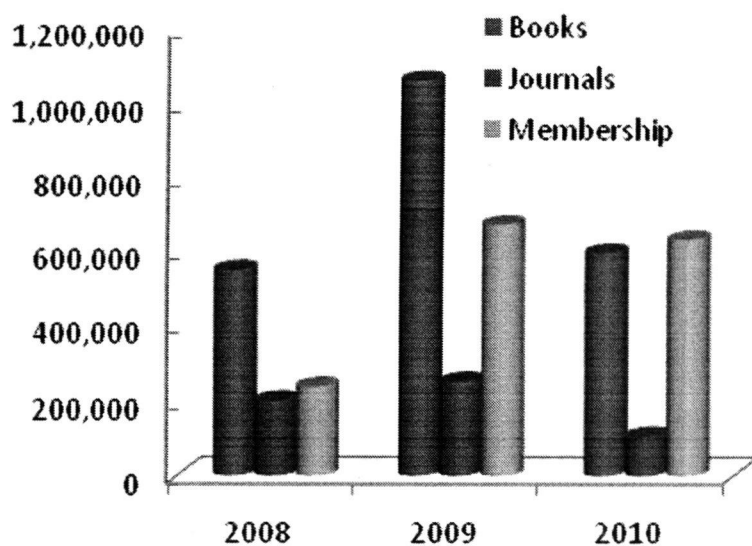
All the books and journals are maintained in a WINISIS data base which are easily searched and accessed using keywords. The library also assists project staff to acquire subscription and membership in professional societies, thereby providing online access to journals for staff members. Leading multidisciplinary journals are available such as *Nature Science*, *New Scientist* etc., providing the latest information on a variety disciplines. Besides printed text, the library also has a collection of CD's, Videos, maps and electronic materials.



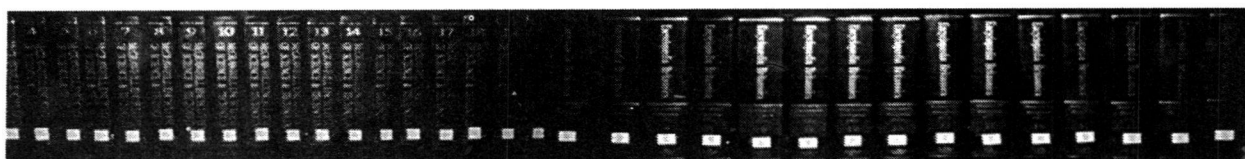
Researchers from other institutes and school students are regular visitors to the library who are assisted to locate information through the data base.

Present collection of the IFS library

Collection	Added during 2010 January-December	Total as on 30 th November 2010
Books	302	5866
Theses	8	94
CDs	11	222
Reports	24	456
Subscription to journals	12	-
Exchange base journal	14	-
Reprints	10	647



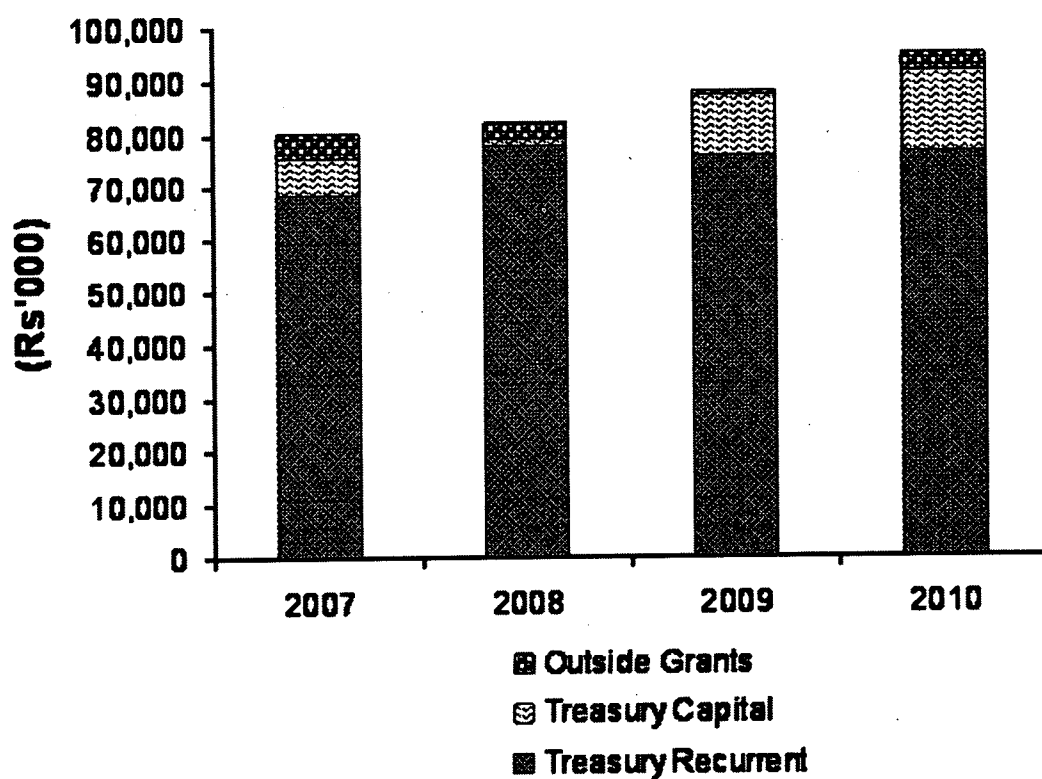
Budget allocation (Rs)for the past few years.



12. BUDGET

Total annual expenditure (Rs'000)

	Item	2007	2008	2009	2010
Recurrent	Personnel Emoluments	49,441	56,107	48,826	51,945
	Traveling Expenses	244	591	338	570
	Supplies	5,247	5,355	7,822	6,763
	Maintenance Expenditure	3,617	4,165	6,035	5,063
	Contractual Services	7,727	11,618	6,043	9,817
	Other Expenses	2,434	237	6,992	2,509
Capital	Capital Expenditure	7,058	1,344	11,216	15,123
Outside Grants	Outside Grants	4,328	2,893	536	2,996
Total		80,096	82,310	87,808	94,786



Budget allocation (Rs)for the past few years.

13. IFS STAFF NEWS 2009-2010

13.1 Recruitments

The following scientists were recruited to the IFS during 2009-10

- | | |
|--|---|
| 1. Prof. (Mrs) N. S. Kumar | - Research Professor |
| 2. Prof. U. L. B. Jayasinghe | - Research Professor |
| 3. Prof. A. Nanayakkara | - Research Professor |
| 4. Prof. J.M.S. Bandara | - Research Professor |
| 5. Prof. G. Seneviratne | - Research Professor |
| 6. Dr. M.C.M. Iqbal | - Senior Research Fellow |
| 7. Dr. S. Benjamin | - Senior Research Fellow |
| 8. Dr. N.D. Subasinghe | - Senior Research Fellow |
| 9. Dr. D.N. Magana-Arachchi | - Research Fellow |
| 10. Dr. R.Ratnayake | - Research Fellow |
| 11. Dr. M. Vithanage | - Research Fellow |
| 12. Prof. S. A. Kulasooriya | - Visiting Research Professor |
| 13. Mr. J. P. Padmasiri | - Visiting Research Fellow |
| 14. Prof. M. A. K. L. Dissanayake | - Visiting Research Professor |
| 15. Prof. Tissa Herath | - Visiting Research Professor |
| 16. Associate Prof. G. K. R. Senadeera | - Visiting Associate Research Professor |
| 17. Dr. W. P. J. Dittus | - Senior Visiting Scientist |

The following were recruited to the IFS administrative staff during 2009-10

- | | |
|-----------------------|-------------------------|
| 1. Samarakoon K.I.K. | - Stenographer Grade II |
| 2. Seneviratne O.W.K. | - Stenographer Grade II |

13.2 New initiatives /collaborations by IFS scientists

- In November 2010, **Dr. N.D. Subasinghe** visited Mahidol University, Bangkok, Thailand and initiated a student-exchange programme. Prof. W. Siripunvaraporn (geophysicist) will host and train two postgraduate students for a period of one year at Mahiadol University.
- Dr. M. Vithanage**. SATREPS (Science and Technology Research Partnership for Sustainable Development): UoP, Saitama University, UoR – JICA – JST grant for 5 years on 'Site-Specific Pollution Control and Remediation Techniques for Waste Dumping Sites in Sri Lanka'.
- Dr. M. Vithanage**. Saitama University, Japan: Prof. Ken Kawamoto – research grant for work on Water repellency behavior of soils
- Dr. M. Vithanage**. Shimane University, Japan: A research collaboration on 'Adsorptive removal of cadmium by Natural Red Earth: Equilibrium and kinetic studies' with a Ph.D. student K. Mahatantila.

13.3 International/National Committees

Membership in national committees

Prof. Asiri Nanyakkara

Committee member -National Committee for Basic Scientific Research at the NSF

Council member - National Research Council of Sri Lanka

Dr. M.C.M. Iqbal

Chairman- General Research Committee of the Sri Lanka Association for the Advancement of Science.

Consultant - Ministry of Environment and Natural Resources, for preparation of the Second National Communication to the United Nations Framework Convention on Climate Change.

Dr. Meththika Vithanage

Committee member- International Participation Committee of the American Geophysical Union for 2 years from 2010.

Dr. Kumari Tilakaratne

Board member – National Committee for Popularization Science NSF

13.4 Visits by IFS Scientists:

D. N. Magana-Arachchi*, R.P.Wanigatunge (2009). Cyanobacterial diversity and toxin production in Lake Gregory, Sri Lanka. *Second Open Science Meeting on HABs and Eutrophication, GEOHAB, 18-21, October, Beijing, China.*

Jayarathna, I.P.L., Weerasooriya, R., Bandara, A., 2009. Synthesis and Characterization of Fe_2O_3 Nanoparticles, 42nd IUPAC Congress, UK., P101-013

Jayasinghe, U.L.B. (2009): "How TITECH – UNESCO Research Fellowship help me to enhance my carrier as a Natural Product Chemist" The Tokyo Tech – UNESCO Fellows Symposium for Development of Human Resources and Research Network in Science and Technology, 10-11th December, Tokyo, Japan.

Jayasinghe, U.L.B. (2009): Search for environmental friendly bioactive compounds from natural sources", Tokyo Institute of Technology, Japan, 12th September.

Jayasinghe, U.L.B. (2010) : Future of plant natural product research in Sri Lanka: Chemistry and bioactivity of some edible fruits, Invited Lecture, International symposium on natural products" to felicitate Profs. V. Kumar and N.S. Kumar, University of Peradeniya, 26th June, 2010.

Jayasinghe, U.L.B. (2010): Invited Lecture – "Chemistry and bioactivity of some edible fruits", 12th International Symposium on Natural Product Chemistry, 22nd-25th, November, Karachi, Pakistan.

Jayasinghe, U.L.B. (2010): Natural Products Research in South Asia: Opportunities for collaboration: Kathmandu Humboldt Kolleg (KHK) on "Colloborative research as an integrative tool for strengthening science and technology in South Asia", November 15-18th Kathmandu, Nepal.

Kumar, N. S. (2010) : "Plant Extracts, Herbal Extracts, Processing and Fine Processing in Sri Lanka" at *International Training Workshop on Botanical Processing Technology*, Sept. 7 – 27 2010, at Hunan Agricultural University P. R. China.

Rajapaksha, A.U., Vithanage, M., Bandara, W.M.A.T. & Weerasooriya, R. Heavy metal release from serpentine soil dissolution: Fractional speciation of Ni and Mn. American Geophysical Union, Fall Meeting, San Francisco, December, 2010.

R. R. Ratnayke visited the National Renewable Energy Laboratory, Colorao. USA, July 2009

Rajapaksha, A.U., Vithanage, M., Bandara, W.M.A.T. & Weerasooriya, R. Effect of organic and inorganic acids on serpentinite soil dissolution; Release of Ni and Mn to the environment. Sources, Transport, and Fate of Trace and Toxic Elements in the Environment, Geological Society of America Annual Meeting, Vol. 42, No. 5, p. 502

Subasinghe, N.D., (2010) Geophysical Applications in Exploration of Groundwater in Hard Crystalline Terrains – An Example from Sri Lanka . *Proc. 2nd Int. Conference on Chemical, Biological and Environmental Engineering (ICBEE 2010)* in Cairo Egypt, November 2010.

Subedi, S., Kawamoto, K., Karunarathna, A.K., Jayarathna, L., Vithanage, M., Komatsu, T. Assessment of water repellency of model sands mixed with oleic acid. 12th International Summer Symposium of Japanese Society for Civil Engineers. September, 2010, Japan

Vithanage, M., P. Engesgaard, K.H. Jensen, J. Obeysekera, K. Villholth and T.H. Illangasekare. Effect of 2004 tsunami on groundwater in a coastal aquifer of Sri Lanka: Tank experiments, field observations and numerical modelling. Invited talk. American Geophysical Union, Fall Meeting, San Francisco, 2009.

W.S.S. Gunathilake, G.K.R. Senadeera* , P. Ekanayake, V. Seneviratne, M.A.K.L. Dissanayake and A.D.L.C. Perera, Quasi Solid-State Nano Composite Polymer Electrolytes based on PVdF-PEO blend and their Applications in Dye Sensitized Solar Cells, 12th Asian Conference on Solid State Ionics, May 2-6, Wuhan, P.R. China., 2010

15. PUBLICATIONS OF IFS MEMBERS 2009-2010

15.1 Publications in refereed journals

Lohwasser, R.H., Bandara, J., and Thelakkat, M., Tailor-made synthesis of poly(3-hexylthiophene) with carboxylic end groups and its application as a polymer sensitizer in solid-state dye-sensitized solar cells. *J. Mater. Chem.*, 2009, 19, 4126.

- Bandara, J., Shankar, K., Paulose, M., Wietasch, H., Varghese, O.K., Mor, G.K., LaTempa, T.J., Grimes, C.A.,** Integration of TiO₂ Nanotube arrays into Solid-State Dye-Sensitized Solar Cells. *European J. of Appl. Physics*, 2010 *in press*).
- Bandara, J.,** Thickness dependence of device parameters in solid state dye sensitized solar cells, *J. Natl. Sci. Foundation, Sri Lanka* 2010 (*in press*).
- Benjamin, S.P.,** (2010). Revision and cladistic analysis of the jumping spider genus *Onomastus* (Araneae, Salticidae). *Zoological Journal of the Linnean Society* 159: 711-745.
- Benjamin, S.P., and Jaleel, Z.,** (2010). The genera *Haplotmarus* Simon, 1909 and *Indoxysticus* gen. nov.: two enigmatic genera of crab spiders from the Oriental region (Araneae: Thomisidae). *Revue suisse de Zoologie* 117: 1-9.
- Benjamin, S.P., and Hormiga G.,** (2009). Phylogenetic placement of the enigmatic genus *Labullinyphia* van Helsdingen, 1985, with redescription of *Labullinyphiaterisa* (Simon, 1894) from Sri Lanka (Araneae: Linyphiidae). *Contributions to Natural History*. 12: 161-181.
- Dimitrov D., Hormiga G., and Benjamin, S.P.,** (2009). A revised phylogenetic analysis for the genus *Clitaetra* Simon, 1889 (Araneoidea, Nephilidae) with the first description of the male of the Sri Lankan species *Clitaetrathisbe* Simon, 1903. *Bull. Museum of Comparative Zoology* 159: 301-323.
- Edwards, G. B., and Benjamin, S.P.,** (2009). A first look at the phylogeny of the Myrmarachninae, with rediscovery and redescription of the type species of *Myrmarachne* (Araneae: Salticidae). *Zootaxa* 2309: 1-29.
- Chandrajith, R., Koralegedara, N., Ranawana, KB., Tobschall, HJ., Dissanayake, C.B.,** Major and trace elements in plants and soils in Horton Plains National Park, Sri Lanka: an approach to explain forest die back. (2009) *Environmental Geology* 57: 17-28.
- Chandrajith R., Kudavidanage, E., Tobschall HJ., Dissanayake, C.B.,** Geochemical and mineralogical characteristics of elephant geophagic soils in Udawalawe National Park Sri Lanka. (2009) *Environmental Geochemistry and Health* 31: 391-400.
- Dissanayake, C.B., Chandrajith, R.,** Phosphate mineral fertilizers, trace metals and human health. (2009) *Journal of the National Science Foundation* 37(3): 153-165.
- Ranasinghe, P.N., Fernando, G.W.A.R., Dissanayake, C.B., Rupasinghe, M.S., and Witter, D.L.,** Statistical evaluation of stream sediment geochemistry in interpreting the river catchment of high-grade metamorphic terrains. *Journal of Geochemical Exploration* (2009) (*in press*)
- Chandrajith, R., Seneviratna, S., Wickramaarachchi, K., Attanayake, T., Aturaliya, TNC., Dissanayake, C.B.,** (2010) Natural radio-nuclides and trace elements in rice field soils in relation to fertilizer application- study of a Chronic Kidney Disease (CKD) area in Sri Lanka. *Environmental Earth Sciences* 60(1), 193-201.
- Chandrajith, R., Nanayakkara, N., Itai, K., Aturaliya, T.N.C., Dissanayake, C.B., Abeysekera T, Harada K, Watanabe, T., Koizumi, A.,** (2010) Chronic Kidney Diseases of Uncertain Etiology (CKDue) in Sri Lanka: geographic distribution and environmental implications, *Environmental Geochemistry and Health* (*in press*)
- Chandrajith, R., Dissanayake, C.B., Ariyaratne, T., Hearsh, HMJMK., Padmasiri, J.P.,** (2010) Dose-dependent Na and Ca in fluoride-rich drinking water - a major cause of chronic renal failure in tropical arid regions. *Science of the Total Environment* (*In Press*) .
- Jayasinghe, U.L.B., Amarasinghe, N.R., Arundathi, B.G.S., Rupasinghe, G.K., Jayathilake, N.H.A.N., Fujimoto, Y.,** (2010); Antioxidant flavonol glycosides from the leaves of *Elaeocarpus serratus* and the fruits of *Filicium decipiens*, *Nat. Prod. Res.* (*in press*)
- Magana-Arachchi, D.N*, Perera, A.J, Senaratne, V., and Chandrasekaran, N.V.,** (2010), Pattern of Drug Resistance and RFLP Analysis on *Mycobacterium Tuberculosis* Strains Isolated From Recurrent Tuberculosis Patients. *Southeast Asian J Trop Med Public Health*. 41(3); 583-589.

Kumar, N.S., Jayaratne, N. B., and Karunaratne, D.N., Effect of caffeine and a tea flavanoid on *Monacrosporiummambrosium*, ectosymbiote of shot-hole borer beetle of tea". (2009), *J. Natl. Sci. Foundation, Sri Lanka* 17(4) 273-275

Kumar, N.S., Wijekoon, W.M.A.M., Kumar, B., Punyasiri, V. N., and Abeysinghe S., Separation of proanthcyanidins from tea leaves using High-speed counter-current chromatography (2009), *J. Chromatogr. A*, 1216, 4295-4302

Asiri Nanayakkara., Senevirathne, M.S., Senadeera, G.R.K., a theoretical investigation of band gaps of conducting polymers with heterocycles *J. Natl. Sci. Foundation, Sri Lanka (in press) 2010.*

Asiri Nanayakkara., Application of Lie transform perturbation method for multidimensional non-Hermitian systems. *Pramana Journal of Physics (2010) ** (in press)

Asiri Nanayakkara., Semiclassical quantization of non-Hermitian 2-D systems: Classical (Lie Transform) perturbation theory. *J. Natl. Sci. Foundation, Sri Lanka* 37 111 (2009)

Ratnayake, R.R., Seneviratne, G., Kulasooriya, S.A., (2010). The effect of cultivation on organic carbon content in the clay mineral fraction of soils. *Int. J. Soil Sci. (accepted).*

Ratnayake, R.R., Seneviratne, G., Kulasooriya, S.A., (2010). Effect of land use and management practices on quantitative changes of soil carbohydrates. *J. Natl. Sci. Foundation, Sri Lanka (accepted).*

Seneviratne, G., Igalavithana, A.D., Sandamali, H.A.J., Henakaarachchi M.P.N.K., and Jayakody, A. N., (2010) Fungal inoculation with clay improves carbon stabilization of tropical forest floor litter. *Environmental Research Journal (in press).*

Weerasinghe, S.M., Chandrasekara, C., Seneviratne, G., Gunatilleke, C.V.S., and Gunatilleke, I.A.U.N., (2010) Growth variations of edaphic specialist species in a reciprocal pot experiment in Sri Lanka. *J. Natl. Sci. Foundation, Sri Lanka* 38: 171-179.

Seneviratne, G., (2009) Collapse of beneficial microbial communities and deterioration of soil health: a cause for reduced crop productivity. *Current Science* 96: 633.

Seneviratne, G., (2009) Effect of forest drought on global warming is enigmatic. *Current Science* 97: 9.

Seneviratne, G., Peyvast, G.A., Olfati, J.A., and Kariminia, A., (2009) *Rhizobia as biofertilizers for mushroom cultivation. Current Science* 96: 1559.

Seneviratne, G., Henakaarchchi, M.P.N.K., Weerasekara, M.L.M.A.W., and Nandasena, K.A., (2009) Soil organic carbon and nitrogen pools as influenced by polyphenols in different particle size fractions under tropical conditions. *J. Natl. Sci. Foundation, Sri Lanka* 37: 67-70.

Ambagahaduwa, I.M., Prasad, N., Gunatilleke, I.A.U.N., Seneviratne, G., and Gunatilleke, C.V. S., (2009) Estimation of above ground biomass of a *Pinus caribaea* Morelet stand in lower Hantana. *J. Natl. Sci. Foundation, Sri Lanka* 37: 195-201.

Ariyasinghe, Y.P.Y.P., Wijayarathna, T.R.C.K., Kumara, I.G.C.K., Jayarathna I.P.L., Thotawattage, C.A., Gunathilake, W.S.S., Senadeera G.K.R., Perera, V.P.S., Efficient Passivation of SnO₂ nano crystallites by indoline D-149 via Dual Chelation., *Journal of Photochemistry and Photobiology A. Chemistry* 2010 (in press.)

Senadeera, G.K.R., Pawel, J. W., Leonardo B.S., Goncalo D., Pedro B., Hugo A., Elvira F., Rodrigo M., Inkjet printed and "doctor blade" TiO₂ photodetectors for DNA biosensors. Iwona Bernacka-Wojcik, *Biosensors and Bioelectronics* (2010) 25 1229-1234.

Subasinghe, N.D., (2010) Applications of Non-Linear Dynamics in the Production of Functionalised and Sensing Material. *Advanced Materials Research, Vols. 93-94, pp 485-488.*

Bhargava, S.K., Garg, A., and Subasinghe, N.D., (2009) *In situ* high-temperature phase transformation studies on pyrite. *Fuel*, 88(6), 988-993.

Subasinghe, N.D., Awaja, F., and Bhargava, S.K., (2009), Variation of kerogen content and mineralogy in some Australian tertiary oil shales. *Fuel*, 88(2), 335-339.

Rajapaksha, A., Vithanage M., Jayarathna L., Kumara C. K., Natural Red Earth as a possible low cost substrate for arsenic removal; Sorption behavior through kinetics and the presence of competing ions. *Special Issue of Appl. Geochemistry*, 2010 (in press).

Vithanage, M., Villholth, K.G., Engesgaard, P., and Jensen, K.H., Sustainability of coastal aquifer systems in the east coast of Sri Lanka; Groundwater balance and safe yield (Manuscript accepted for the *Special Issue of Journal of Open Hydrology*, 2010).

Kohta G., Kenji F., Akitsugu, S., Tadao, S., Kazumasa K., Kenneth, E. G., Katie H., Wolfgang Dittus, Lauren, A. M., Michael L. P., Olav T.O., Tadasu U., (2010). Chemical characterization of oligosaccharides in the milk of six species of New and Old world monkeys. *Glycoconjugate Journal*, 2010, 27 (7-9): 703-715.

15.2 Chapters in books

1. **Dissanayake, C.B.**, Rao, C.R.M., and Chandrajith, R., (2010) Some aspects of the medical geology of the Indian subcontinent and neighboring regions. In: *Selinus O, Finkelman RB, Centeno JA (eds.) Medical Geology-A Regional Synthesis. Chapter 7, Springer, Heidelberg, Germany (ISBN: 978-90-481-3429-8).*
2. Seneviratne, G., Weerasekara, M. L. M. A. W., and Zavahir, J. S., (2010). Microbial Biofilms: How Effective in *Rhizobium*-Legume Symbiosis? In: Khan, M. S., Zaidi, A. and Musarrat, J. (eds.) *Microbes for Legume Improvement*. Springer-Verlag/Wien, pp. 123-136.
3. Seneviratne, G., Weerasekara M. L. M. A. W., Seneviratne, K.A.C.N., Zavahir, J. S., Kecskés, M.L. and Kennedy, I.R. (2010) Importance of biofilm formation in plant growth promoting rhizobacterial action. In: Maheshwari, D. K. (ed.) *Plant Growth and Health Promoting Bacteria, Microbiology Monographs 18 (Springer series)*, Springer-Verlag Berlin Heidelberg, pp. 81-96.
4. Seneviratne, G., Thilakarathne, R.M.M.S., Jayasekara, A.P.D.A., Seneviratne, K. A. C. N., Padmathilake, K. R. E. and De Silva, M.S.D.L. (2009) Developing beneficial microbial biofilms on roots of non-legumes: A novel biofertilizing technique. In: Khan, M. S., Zaidi, A. and Musarrat, J. (eds.) *Microbial Strategies for Crop Improvement*. Springer-Verlag, Germany, pp. 51-62.
5. Dabrowska, B.B., Vithanage, M., K.R. Gunaratna, A. B. Mukherjee and P. Bhattacharya. Bioremediation of arsenic by plants in contaminated soils and aquatic environment; A synoptic review. *Environmental Chemistry (in press)*, Vol. 2, 2010. Springer, The Netherlands.
6. Molden, D. and Vithanage, M. Water in Agriculture. In *Treatise on Water Science*. Eds: P. Wilderer and T. Vereijken. Elsevier Science (in press).

15.3 Documentary Film Production: 2009 -2010

Dr. W. Dittus and team of assistants at Polonnaruwa. Production (by NHNZ) of a series of 14 half-hour films about monkey behaviour. The series, entitled "Dark Days in Monkey City," is being broadcast internationally on the Animal Planet, Discovery Channel.

15.4 M. Phil. Theses

Mr. P. Bandarasamarasinghe

Synthesis and characterization of lithium transition-metal oxide electrode materials and their applications in Li-ion batteries (2009)

Supervisors Dr. H.W.M.A.C. Wijyasinghe and M.A.K.L. Dissanayake

Ms. D.C. GunawardenaChemistry and Biochemistry of the fruits of *Averrhoa carambola* (2010)*Supervisor Prof. Lalith Jayasinghe***Mr. I.G.C.K. Kumara**

Synthesis, properties and applications of Nano Gibbsite crystals. A substrate for arsenate remediation (2010).

*Supervisor Prof. Rohan Weerasooriya***Ms. S. K. Premaratne**

Isolation of endophytic fungi of seaweeds from the coastal areas of Sri Lanka: A study on their chemistry and biological activities (2009)

*Supervisor Prof. HRW Dharmaratne***Ms. S. Zahmeeth Sakka**

Brain Computer Interface (BCI) based on Electroencephalographic (EEG) patterns due to new cognitive tasks. (2010)

*Supervisor Prof. Asiri Nanayakkara***PAPERS UNDER REVIEW**Benjamin S.P., (2010) Phylogenetics and comparative morphology of crab spiders (Hraneae: Dionycha, Thomisidae) *Zootaxa*.Gunawardena, D.C., Jayasinghe, U.L.B., Hara, N., Fujimoto, Y., (2010): Phytotoxic constituents of the fruits of *Averrhoa carambola*. *Nat. Prod. Res.*Jayasinghe, U.L.B., Lakdusinghe, M., Hara, N., Fujimoto, Y., (2010): Phenolic constituents from the fruit juice of *Flacourtia inermis*. *Nat. Prod. Res.*Hettihewa, S.K., Kumar, N.S., Bandara, B.M.R., Panagoda, G.J., (2010): High-speed counter-current chromatography separation and antibacterial activity of oligomeric proanthocyanidins from tea leaves (2010), *J. Chromatogr. A*Magana Arachchi D. N., and Liyanage, H.M., (2010) Identification of Cyanotoxins: An Avenue to the Unveiled Mystery of Chronic Kidney Disease of unknown aetiology *J. Natl. Sci. Foundation Sri Lanka*.Magana Arachchi D.N*, Wanigatunge, R.P., and Chandrasekharan, N.V., (2010) Morphological and phylogenetic diversity of cyanobacteria in the hot springs of Mahapelessa, Sri Lanka. *Current Science*.Magana Arachchi D.N*, Wanigatunge R.P., and Liyanage, H.M., (2010) Molecular characterization of cyanobacterial diversity in Lake Gregory, Sri Lanka. *Chinese J. of Oceanol. and Limnol.*Magana Arachchi D.N¹, Valarmathy, A., De Silva, C., Medagedara, D., & Thevanesam, V., (2010) Detection of Isoniazid –dissociated Rifampin resistance in *Mycobacterium* isolates from Kandy, Sri Lanka; results of antibiotic sensitivity testing and *rpoB* gene analysis. *Microbial Drug Resistance*Ratnayake, R.R., Seneviratne, G., Kulasoorya, S.A., (2010). Effect of soil carbohydrates on nutrient availability in natural forests and cultivated lands in Sri Lanka. *Current Science*.Wijayarathna, T.R.C.K., Ariyasinghe, Y.P.Y.P., Senadeera, G.K.R., Perera, V.P.S., Kumara, C.K.K., Thotawatthage, C.A., Jayarathna, I.P.L., Samantilleke A.P. (2010) Use of Surface Plasmon Resonance of gold nanoparticles in the efficiency enhancement of dye sensitized solar cells with TiO₂, *Solar Energy Materials and Solar Cells*.

Jinadasa, S.U.P., and Subasinghe, N.D., (2010)

Integrating magnetic, resistivity, and self potential techniques to explore groundwater bearing fracture zones in the hard crystalline terrain of Monaragala, Sri Lanka. *Applied Geophysics*.

Subasinghe, N.D. and Jinadasa, S.U.P., (2010)

Demarcation of salt and freshwater interface in coastal zone by means of 2D resistivity imageries. *Applied Geophysics*.

ABSTRACTS AND CONFERENCE PROCEEDINGS

Abeykoon, P.D.G.A.K., Jayasinghe, U.L.B., and Bandara, B.M.R., (2010): Endophytes from the healthy leaves of *Syzygium samarangense*; isolation and bioactive extracts. *Proceedings of the Peradeniya, University Research Sessions, (PURSE)* December.

Ekanayake, W.M.S.M., Jayasinghe, U.L.B., (2010): Search for Bioactive Compounds from Endophytic fungi isolated from the leaves of *Artocarpus heterophyllus* Lam. *Proceedings, Research Symposium, Uva-Wellassa University*, September.

Jayasinghe, U.L.B., (2010): High Performance Liquid Chromatography, Workshop on Instrumentation for Technical Officers - IFS. 29-30, October 2009

Marasinghe, M.M.N.K., Jayasinghe, U.L.B., Wimalasiri, K.M.S., (2010): Development of a Wine from Tamarind (*Tamarindus indica*), a value added product from an underutilized fruit crop in Sri Lanka, *Proceedings, Research Symposium, Uva-Wellassa University*, September.

Alakolanga, A.G.A.W., Jayasinghe, U.L.B., Kumar, N.S., (2010): Isolation of proanthocyanidin from the fruits of *Flacourtia inermis*, (*PURSE*) 15, December 16th, 475-477

Kumara, C.K., NG, W. Bandara, J., Weerasooriya, A., R., 2009, Physio-Chemical Properties of Gibbsite Nano-Crystals, 42nd IUPAC Congress, UK. P101-012.

Kumara, C.K., Bandara, A., Weerasooriya, R., 2009, Progression of Gibbsite Nanocrystals, (*Proc. SLAAS*) 65th Annual session, Sri Lanka

Bandara, H.M.S.K.H., Kumar, N.S., and Jayasinghe, U.L.B. (2010): Bioactivity studies of the extracts isolated from a fungus associated with *Musa sp.* (*PURSE*) 15, December 16th p.20-21.

Siriwardane, A.M.D.A., Kumar, N.S., Jayasinghe, U.L.B. (2010): Bioactive extracts from a fungus isolated from the seeds of *Limonia acidissima* (*PURSE*) 15, December 16th, p 473-474

Padmathilake, K.G.E., Kumar, N.S., and Jayasinghe, U.L.B., (2010): Bioactive compounds from the fruits of *Pouteria campechiana*. (*PURSE*) 15, December 16th. p 508-510

Fernando, W.I.T., Perera., H.K.I., Athauda, S.B.P., Kumar, N.S., Jayasinghe, U.L.B., Sivakanesan, R., (2010): In-vitro screening of spices for lipase inhibitory activity and antioxidant activity. (*PURSE*) 15, December 16th, p383-385

N.S. Kumar., and Jayasinghe, U.L.B., (2010): Determination of antifungal, phytotoxic, cytotoxic and antioxidant activities, Workshop on "Bioassays for Natural Product Research", Institute of Fundamental studies, 25-26th March, 2010.

Wanigatunge, R.P., Magana-Arachchi, D.N., * and Chandrasekharan, N.V., (2010). Phylogeny of order Oscillatoriales (cyanobacteria) isolated from Sri Lanka based on 16S rDNA sequence analyses. *Proc. Sri Lanka Assoc. Adv. Sci (Proc. SLAAS)*. 66th Annual Session: 42/D, p 68.

Liyanage, H.M., Magana-Arachchi, D.N., Kulasoorya, S.A., Chandrasekharan, N.V., and Wanigatunge, R.P., (2010). Detection of cyanotoxin; microcystin from Kandy Lake with molecular and biochemical methods. (*Proc.SLAAS*).. 66th Annual Session: 43/D, p 69.

Ratnatake R.R., Seneviratne, G.Kulasooriya, S.A., (2009). Soil C sequestration in labile organic and stable mineral fractions of natural forests and cultivated lands in Sri Lanka, In Proceedings of the International Symposium on Organic matter Dynamics, Land use, management and global change, Colorado, USA, 6-9 July 2009.

Bernacka-Wojcik, R. Albuquerque, J. Pinto, L. Silva, P. J. Wojcik, R. Senadeera, G. Doria, H. Aguas, P. Baptista, R. Martins, E. Fortunato, Towards price reduction in biodetection,

II Annual Meeting of the Institute of Nanostructures, Nanomodelling and Nanofabrication, 5-6 February 2010, Fatima, Portugal.

P. J. Wojcik, I. Bernacka Wojcik, R. Senadeera, P. Baptista, E. Fortunato, R. Martins. Inkjet printed titanium dioxide for dye sensitized photodetectors. Plastic Electronics Europe 2009, Maritim Dresden, Germany, 27-29 October 2009.

Gunathilake, W.S.S., Senadeera, G.K.R.,* Ekanayake, P., Seneviratne, V., Dissanayake, M.A.K.L., and Perera, A.D.L.C., Quasi Solid-State Nano Composite Polymer Electrolytes based on PVdF-PEO blend and their Applications in Dye Sensitized Solar Cells. Solid State Ionics, *Fundamental Researches and Technological Applications (2010)* p 1167-1174, Ed: B.V.R. Chodari, H. Liu, W. Chen, Q. Xu and Z Yu.

Anushka, P.V.A., Magana Arachchi D.N.,*, Wanigatunge, R.P., and Amarasinghe, A.A.Y., (2010). Identification, extraction and analysis of cyanobacterial toxins in Kalawewa and Nachchaduwa fresh water tanks of Sri Lanka. (*Proc. SLAAS*). 66th Annual Session, 411D, P67.

Kokila, K.W.A.M., and Magana-Arachchi, D.N., *(2010). Isolation and identification of Mycobacterium in Soil and Water. Value Addition to the National Resource Base. *Proc. Research Symposium of Uva Wellassa University*, 16-17 th September. P147.

Magana-Arachchi D.N., Wanigatunge, R.P., (2009). Cyanobacterial diversity and toxin production in Lake Gregory, Sri Lanka. *Second Open Science Meeting on HABs and Eutrophication, GEOHAB, 18-21, October, Beijing, China*.

Wanigatunge R.P., & Magana-Arachchi D.N., (2009). Detection of potential microcystin-producing cyanobacteria of order Oscillatoriales, from Mahapelessa hot springs, Hambantota. (*Proc. SLAAS*). 65th Annual Session

Bernacka-Wojcik, I., Senadeera, R., Wojcik, P.J., Silva, L.B., Doria, G., Baptista, P., Aguas, H., Fortunato, E., Martins, R. Oral presentation, gold nanoparticles to "toothpaste" for DNA detection. Workshop Nano 09, 10-11 December 2009, Braga, Portugal.

Bernacka-Wojcik, I., Senadeera, R., Wojcik, P.J., Silva, L.B., Doria, G., Baptista, P., Aguas, H., Fortunato, E., Martins, R. Inkjet printed and "doctor blade" TiO₂ photodetectors for DNA biosensors, Biosensors 2010 Congress, 26-28 May 2010, Glasgow, United Kingdom.

Premachandra B.A.J.K., De Alwis, A.A.P., and Senadeera, G.K.R., Attanayake, C.I.F., Conversion of Solar Energy to Electricity by Natural Dye-Sensitization. 15th ERU Symposium, 2009: Faculty of Engineering, University of Moratuwa.

W.S.S. Gunathilake, G.K.R. Senadeera, P. Ekanayake, V. Seneviratne, M.A.K.L. Dissanayake and A.D.L.C. Perera. Quasi Solid-State Nano Composite Polymer Electrolytes based on PVdF-PEO blend and their Applications in Dye Sensitized Solar Cells, 12th Asian Conference on Solid State Ionics, May 2-6, Wuhan, P.R. China.

Wijesinghe, K.R.N.L., Seneviratne, G., and Jinadasa, D.M., (2010) Biofilmed biofertilizers for sugarcane (*Saccharum officinarum*). In. *Proc. Research Symposium 2010. Faculty of Agriculture, Rajarata University of Sri Lanka, Anuradhapura*. 4 June 2010. p. 43.

Samarakoon, A.M.R.T., Seneviratne, G., and Yapa, P.I., (2010) The effect of biofilmed biofertilizers on the soil-plant-microbes interactions in nursery tea. In. *Proc. 3rd Int. Symp, Sabaragamuwa University of Sri Lanka, Belihuloya*. 26-28 August 2010. p. 44.

Peries, C.M., and Seneviratne, G., (2010). Development of biofilmed biofertilizers for bean (*Phaseolus vulgaris*). In. *Proc. Res. Symposium 2010, Uva Wellassa University, Badulla*. 16-17 September 2010.

Subasinghe, N.D., (2010) Geophysical Applications in Exploration of Groundwater in the Hard Crystalline Terrains – An Example from Sri Lanka. *Proc. 2nd Int. Conference on Chemical, Biological and Environmental Engineering (ICBEE 2010)* in Cairo. Egypt, November 2010.

Hobbs, B.A., Fonseka, M., Dawes, G., Johnson, N., Subasinghe N.D., Whaler K., (2010) Geothermal and Tectonic studies in Sri Lanka using Magnetotellurics. *Proc. 20th IAGA WG 1.2 Workshop on Electromagnetic Induction in the Earth*, Giza, Egypt, September 18-24, 2010.

Gamage, P.A.S., Wijesekara, S.S.M.D.H.R., Sarathchandra, G.W.N.L., Basnayake, B.F.A., Costa, W.A.J.M., Leaching from lysimeter simulation of rice straw landfill bioreactor and evaluation of fertilizer quality of resulting compost. 22nd Annual Congress Post Graduate Institute of Agriculture, 2010.

Rajapaksha, A.U., Vithanage, M., Bandara, W.M.A.T., & Weerasooriya, R., Heavy metal release from serpentine soil dissolution: Fractional speciation of Ni and Mn. *American Geophysical Union*, Fall Meeting, San Francisco, December, 2010.

Rajapaksha, A.U., Vithanage, M., Bandara, W.M.A.T., & Weerasooriya, R., Effect of organic and inorganic acids on serpentinite soil dissolution; Release of Ni and Mn to the environment. Sources, Transport, and Fate of Trace and Toxic Elements in the Environment, *Geological Society of America Annual Meeting*, Vol. 42, No. 5, p. 502

Subedi, S., Kawamoto, K., Karunarathna, A.K., Jayarathna, L., Vithanage, M., Komatsu, T., Assessment of water repellency of model sands mixed with oleic acid. 12th Int. Summer Symposium Japanese Society for Civil Engineers. September, 2010, Japan

Rajapaksha, A., Vithanage, M., Jayarathna, L., Kumara, C. K., Natural Red Earth as a possible low cost substrate for arsenic removal in water; comparison of laboratory controlled and uncontrolled conditions. Arsenic in geosphere and human diseases. Jean, Bundschuh and Bhattacharya (eds) Proceedings of As, 2010, Taiwan. Taylor and Francis Group, London

Vithanage M., Ramanayake, A., Rajapaksha, A., Jayarathne, L., Kumara, C.K., Premathilake, M., Ranjith, AD., Hewawasam, T.; Hydrogeochemical characteristics of groundwater in Hambantota District, Sri Lanka. *Annual Sessions Geological Society of Sri Lanka*, Feb. 26th 2010, Colombo.

Vithanage, M., Engesgaard, P., Jensen, K.H., Obeysekera, J., Villholth, K. and Illangasekare, T.H.. Effect of 2004 tsunami on groundwater in a coastal aquifer of Sri Lanka: Tank experiments, field observations and numerical modelling. Invited lecture. *American Geophysical Union*, Fall Meeting, San Francisco, 2009.

Gamage, P.A.S., Wijesekara, S.S.M.D.H.R. Sarathchandra, G.W.N.L., Basnayake, B.F.A., Costa, Leaching from lysimeter simulation of rice straw landfill bioreactor and evaluation of fertilizer quality of resulting compost. 22nd Annual congress of the Post Graduate Institute of Agriculture, 2010.

Rajapaksha, A.U., Vithanage, M., Bandara, W.M.A.T. & Weerasooriya, R. Heavy metal release from serpentine soil dissolution: Fractional speciation of Ni and Mn. *American Geophysical Union*, Fall Meeting, San Francisco, December, 2010.

Rajapaksha, A.U., Vithanage, M., Bandara, W.M.A.T. & Weerasooriya, R. Effect of organic and inorganic acids on serpentinite soil dissolution; Release of Ni and Mn to the environment Sources. Transport, and Fate and Toxic Elements in the Environment, *Geological Society of America Meeting*, Vol. 42, No. 5, p. 502

Jayarathna, I.P.L., Weerasooriya, R., Bandara, A., 2009, Synthesis and Characterization of Fe₂O₃ Nanoparticles, 42nd IUPAC Congress, UK., P101-013

Wijayarathna, T.R.C.K., Ariasinghe, Y.P.Y.P., Jayarathna I.P.L., Thotawathage, C. A., Nishantha M.R., Senadeera G.K.R. and Perera V.P.S.. Effect of surface plasmon resonance of Au nano-particle in the TiO₂ films of Dye sensitized photo electrochemical solar cells. Annual Academic Sessions of Open University of Sri Lanka, 2009, 05.

Nupearachchi, C., Wijayarathna, T.R.C.K., and Perera V.P.S., Utilization of natural henna as a sensitizer in photo electrochemical solar cells; 2010, 505E1.

Gunasekara, H.D.N., Wijayarathna, T.R.C.K., Ariasinghe, Y.P.Y.P., Senadeera, G.K.R., Synthesis and characterization of polymer electrolytes for dye sensitized solar cells;

Research symposium: Value addition to the national resource base; Uwa Welassa University, Sri Lanka; 16th – 17th September 2010; 154.

Suganthy, P., Wijayarathna, T.R.C.K., Ariasinghe, Y.P.Y.P., Senadeera, G.K.R., Identification and characterization of natural dyes available in Sri Lanka. And their usage in low cost dye sensitized solar cells; Research symposium: value addition to the national resource base; Uwa Welassa University, Sri Lanka; 16th – 17th September 2010; 153.

16. IFS STAFF 2010

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Secretary : **Mr. K.T. Waisundara**

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Prof. J.M.S. Bandara
Prof. C.B. Dissanayake
Prof. U.L.B. Jayasinghe
Prof. N.S. Kumar
Prof. A. Nanayakkara
Prof. P.R.G. Seneviratne

Associate Research Professor

Prof. G.K.R. Senadeera

Senior Research Fellow

Dr. S.P. Benjamin
Dr. M.C.M. Iqbal
Dr. N. D. Subasinghe

Research Fellow

Dr. D. Magana-Arachchi
Dr. R.R. Ratnayake
Dr. M.S. Vithanage

Visiting Research Professor

Prof. M.A.K.I. Dissanayake
Prof. T.R. Herat
Prof. S.A. Kulasooriya
Mr. J. Padmasiri

Visiting Scientist

Dr. Dittus W.P.J.

Research Assistants grade I

Liyanage H.M.
Madanayake M.P.
Zahmeeth S.S

Research Assistants grade II

Akilawasan J.
Ariyasinghe Y.P.Y.P
Batawita Acharige S.G.
Chanturanga P.K.D.
De Silva B.A.C.
Herath H.M.L.I.
Jayaratna I.P.L.
Nimalsiri T.B.
Panapitiya G.U.
Rajapakse R.M.A.U.
Siriwardhana A.M.D.A.

Suriyaarachchi N.B.
Wanigathunga R.P.
Wasalamuni W.A.D.D.
Wijesekara S.S.R.M.D.H.R.
Wijethunga S.H.D.P.
Alakolanga A.G.A.W.
Bandara H.M.S.K.H.
Buddhika U.V.A.
De Silva E.D.
Gunatilake K.M.D.

Herath H.M.P.S.
Kumaratunge M.D.P.K.
Perera M.B.U.
Padmatilake K.G.E.
Sandamali P.M.H.
Subasinghe A.
Totawattage C. A.
Wasana H.M.S.
Weeraratne K.N.S.
Wijayarathna T.R.C.K.
Wijeratne W.M.K.T.

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Weerakoon W.M.R.B.

Senior Staff Technical Officer

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Athukorale N.P.	Opatha S.
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Seneviratne O.W.K. - Stenographer Grade II

Colombo Office

Rajapakse M.C. - Coordinator cum Scientific Officer
Gunawardena A.D. - Driver cum KaryalaKaryaSahayaka

Accounts Division

Samarakkody P.S.S. - Senior Assistant Accountant
Sirimalwatta S. - Senior Staff Assistant (Stenographer)
Nissanka M.K. - Staff Assistant (Book Keeper)
PalliyaGuruge M.P. - Senior Staff Assistant (Clerical)
Rathnayake R.M.V.P. - Staff Assistant (Clerical)
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Perera M.A.P. - Office Machine Operator Grade I

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Hettiarachchi T.P. - Senior Staff Assistant (Stenographer)
Weerasooriya R.P.M. - Senior Staff Assistant (Clerical)
Illangakoon C. - Staff Assistant (Stenographer)
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Hapukotuwa R.B. - Laboratory Attendant -Higher Grade
Lal M.A. - Laboratory Attendant -Higher Grade
Kumara A.V.A.P. - Machinist Grade I
Dharmasena G.D. - Electrician Grade II
Dorakumbura D.G.K. - Mason grade II
Herath Banda H.H.M. - Painter Grade II

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Ariyawansa K.M. - Driver-Special Grade
Basnayake G.A.R. - Driver-Special Grade
Dayasiri M.G. - Driver-Special Grade
Jayaweera A.B.G.W. - Driver-Special Grade
Nawarathne Y.G. - Driver-Special Grade
Somananda M.A.G. - Driver-Special Grade
Gunasekara .K.G.T.B. - Driver Grade I
Gunawardena R.S.K. - Driver Grade I

Science dissemination unit

Dr. Tilakaratne C.T.K. - Coordinator
Karunadasa K.K. - Audio visual Assistant
Samarakoon K.I.K. - Stenographer Grade II