INSTITUTE OF FUNDAMENTAL STUDIS

ANNUAL REPORT

2013

Iistitute of Fundamental Studies
Hantana Road
Kandy

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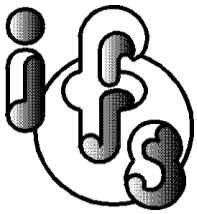

ANNUAL ACCOUNTS

2013

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MESSAGE FROM THE DIRECTOR

I have great pleasure in sending this message on the occasion of the 2013 Annual Research Sessions of the Institute of Fundamental Studies. The progress achieved during the year under review has been very good and the research carried out at the IFS has made a significant impact on the development of the country. Basic research leading to useful applications in a variety of scientific fields, notably in production of environment friendly fertilizer and provision of clean water has made excellent progress. The research scientists of the IFS have published their findings in reputed international journals and the Institute has gained wide recognition as a leading research centre. From the years 1985 to 2013, 646 research articles have been published by 100 employees at IFS. **Figure I** below illustrates the distribution of publications over the span of 28 years.

A large number of research assistants are now carrying out their scientific research leading to postgraduate degrees. The number of younger students who work at the IFS has increased considerably during 2013 and all universities in Sri Lanka have benefitted from our training programmes. The Science Dissemination Unit (SDU) has had another excellent year and many school children and teachers have taken part in the SDU programmes in Kandy and outstations. International collaboration has also been strengthened and the Japanese International Corporation Agency (JICA) has donated very valuable scientific instruments to the IFS and we thank them most sincerely for their kind gesture.

I wish the IFS 2013 Annual Research Sessions all success.

C. B. Dissanayake

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

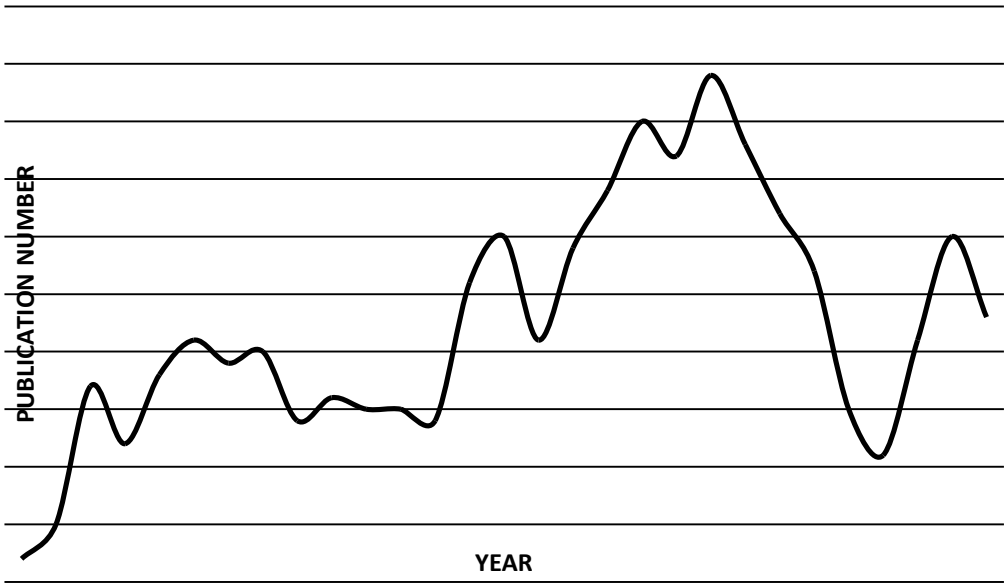

Figure 1

Source - *Science Citation Index Database*

Compiled by Crisenthiya, I., Clayton, Sachini Perera, Benjamin, Suresh P. *Ecology and Environment Biology* Project IFS, Kandy

INSTITUTE OF FUNDAMENTAL STUDIES
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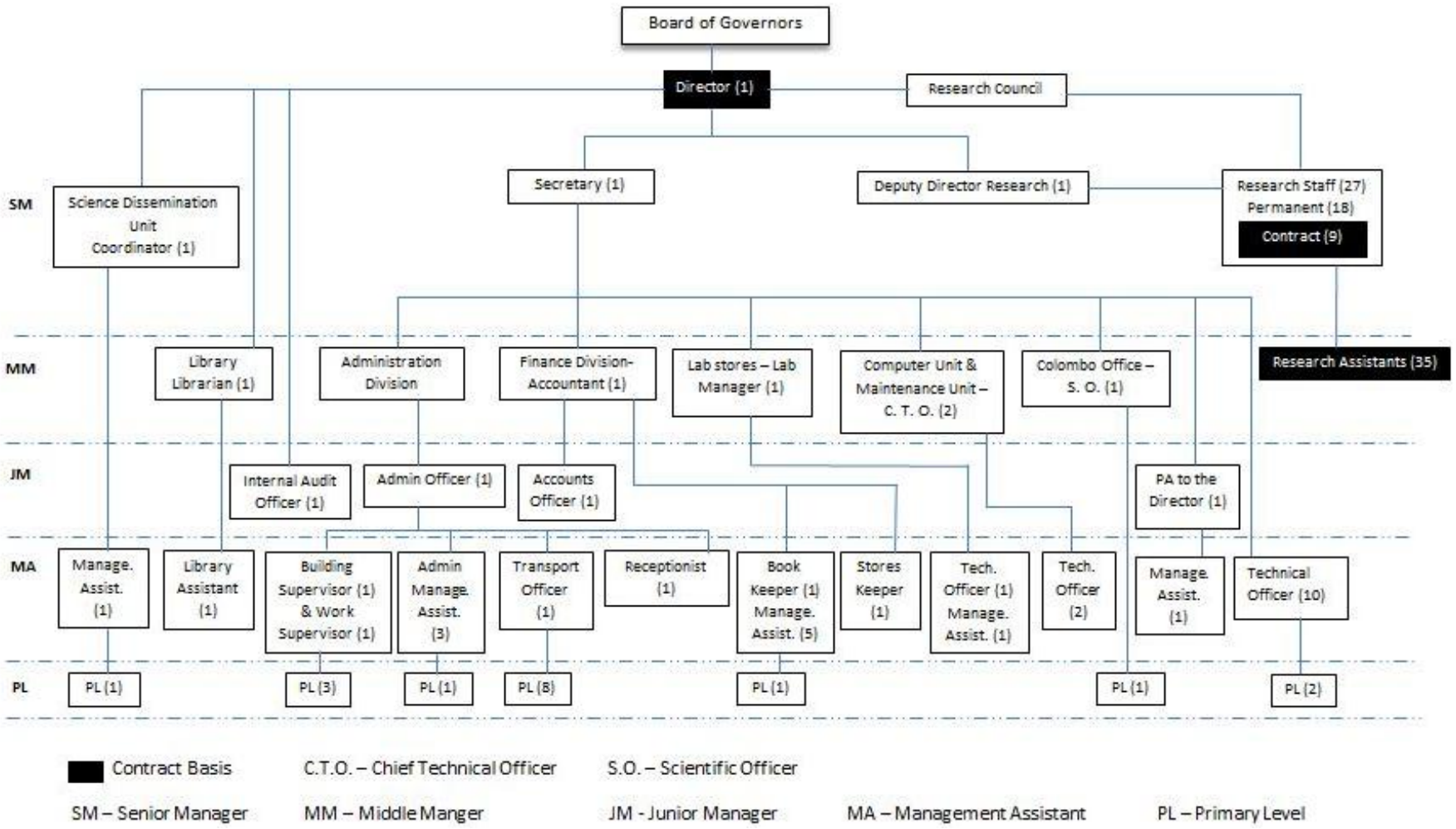


GENERAL INTRODUCTION

Prof. C.B. Dissanayake, Director, IFS

The Institute of Fundamental Studies, under the able guidance of H.E. the President Mahinda Rajapaksa as the Chairman has during the year under review, achieved significant progress. The priority projects, namely the development of environment friendly biofertilizers, provision of defluoridated and low hardness water to the people of the dry zone affected by the kidney disease of unknown etiology have yield very good results. The efforts of the Consultative and Collaborative Division (CCD) is indeed laudable with the production of biofilmed biofertilizers (BFBF) and microbial biofertilizers in particular, yielding excellent results. While the applications are carried out with other state and private sector organizations, the IFS scientists have been solely responsible for the basic research carried out.

The Science Dissemination Unit (SDU) organized an all island competition 'Understanding the world through science' aimed at promoting science concepts among teachers and students to enhance their inquiring mind towards science. The Hon. Minister was present on this occasion. The SDU also distributed a tabloid among school children, with 130,000 copies being given free of charge. The work of the SDU has been highly acclaimed.

As a leading research institute in the country, collaborative research with universities both local and foreign, state sector research organizations and private companies have been strengthened. The universities in particular have supported the IFS activities and the IFS in return has trained a large number of postgraduate students enrolled in the universities for their degrees.

The technical officers of the IFS have been able to conduct training programmes for laboratory technicians of other organizations such as universities and these workshops have been extremely successful. Further workshops will be conducted in 2014. There is indeed a dearth of trained technical officers in the country and the initiative taken by the Institute of Fundamental Studies to alleviate this deficiency has met with good response from the beneficiaries.

As a research institute with good analytical facilities, the institute has been able to support other organizations who require good analytical data for their projects. The water analysis carried out by IFS has been of immense benefit to some institutions who depend heavily on good water quality data for their activities.

I wish to thank the Chairman of the Institute of Fundamental Studies, H.E. the President Mahinda Rajapaksa, the Minister of Technology and Research, Hon. Patali Champika Ranawaka and the Secretary Mrs. Dhara Wijayatilake for their guidance and support rendered.

I also wish to thank the Board of Governors and the Research Council for their serious commitment towards the progress of the Institute of Fundamental Studies.

Leading the IFS Teams…

From Left to Right

1st row

Dr. P.S.B. Wanduragala (Secretary-IFS), Prof. M.A.K.L.Dissanayake, Prof. S.A.Kulasooriya, Prof. C.B.Dissanayake (Director-IFS), Prof. N.S.Kumar, Prof. U.L.B.Jayasinghe

2nd row

Dr. W.P.J. Dittus, Dr. H.W.M.A.C. Wijesinghe, Prof. P.R.G.Seneviratne, Dr. C.T.K. Tilakaratne (Head, Science Dissemination Unit), Prof. J.M.S.Bandara, Dr. M.C.M.Iqbal, Dr. R.Liyanage, Dr. V. Waisundara, Dr. R.R.Rathnayake, Dr. N.D.Subasinghe, Dr. S.P.Benjamin, Prof. G.K.R. Senadeera, Ms. P.S.S. Samarakkody (Deputy Accountant), Dr. D.N.MaganaArachchi, Ms. T.C.P. Tilakaratne (Assistant Librarian), Prof. A.Nanaykkara, Dr. M.Vithanage

Absent: Mr. J.P. Padmasiri

IFS Staff Mmbers…

7.1 ALTERNATIVE AND RENEWABLE ENERGY

7.1.1 BIOFUEL PRODUCTION

Project Leader: Dr. Renuka Ratnayake *(Research Fellow)*

Improvement of microbial strains and biofilms for ethanol production from cellulosic substrates

Biofuels are promising candidates for alternative renewable energy. Lignocellulosic materials from plants are a rich source of sugars. However, currently their utilization for biofuel production is not economical due to the need for pre-treatment. The biofuel project aims to explore the microbial flora of Sri Lanka to isolate efficient degraders of cellulose, hemicellulose and lignin, study the effect of biofilms and/or co-cultures on degradation and utilize aquatic weeds as substrates.

Soil carbon sequestration and management

Many studies on reducing emissions of carbon dioxide and other greenhouse gases have focused to mitigate the danger of global warming. Because artificial techniques are hard to be implemented and very expensive, more attention has been paid to natural processes. Carbon can be stored for hundreds to thousands of years in carbon pools through carbon sequestration, the natural way of absorbing atmospheric CO_2. Forests, soils, oceans and atmosphere are agents for storage of carbon. Among them, soil acts as a significant C sink that absorbs more C than the others. The total soil C pool of 2300 Pg is three times that of the atmospheric pool of 770 Pg and 3.8 times that of the vegetation pool of 610 Pg (Sign et al., 2011). But, much less attention has been given to the potential for sequestering significant amounts of carbon in the soil as an alternative means of offsetting the effects of future emissions of greenhouse gases to the atmosphere. Three sub projects under soil C sequestration and management will be looking at minimizing carbon loss and maximizing the retention of carbon in soils of different vegetation systems.

Soil Carbon Sequestration in forest and tea plantations

The world' total are of fast growing, industrial forest plantations cover around 54.3 million hectares and this is increasing annually to supply the growing demand for wood and lumber. Form these *Eucalyptus* genus is the most planted hardwood in tropical regions, covering more than 20 million hectares (Forest Stewardship Council, 2012). Even in Sri Lanka Eucalyptus is one of the highly grown forest plantation species, because of its high growth rate and adaptability to many environments. Eucalyptus plantations are mainly established in degraded lands in Sri Lanka for the rehabilitation. Other than that they are grown to obtain sawn timber, transmission poles, railway sleepers and fuel wood. But currently new value is added to these plantation forests because they have been identified as fast-response carbon sinks which would support in mitigating the rising levels of atmospheric carbon dioxide. Many factors are influencing for the process of sequestering carbon in plantation forest soil. One major parameter could be stand age of the plantation forests because, many physical and chemical characteristics depend on it. So in this study we expect to find the effect of age of the plantation forest to its soil carbon sequestration. Since *Eucalyptus grandis* is one of the most grown species in plantation forests in Sri Lanka, we are studying the effect of age on carbon sequestration in *E. grandis* forest plantation. Simultaneously we are comparing the forest plantation carbon sequestration with an adjacent patana grass land (Previous land use of studied sites), Natural forest and a tea estate.

Land use and carbon sequestration in North Sri Lanka

Soil structure is an important property to be evaluated because it mediates many biological and physical processes in soils. Since it also influences sequestration of C, it is important to maintain a good soil structure to reduce the environmental impact of agricultural practices. The benefits of these practices vary among regions, soil taxonomy, soil texture and climatic conditions. Therefore,studies on regional level are important. Tropical agriculture is highly diverse. The potential to sequester C in tropical agricultural environments differs from those in temperate regions. The objectives of this study is to quantify and compare the available soil nutrients, soil texture and structural stability under different agricultural land use practices in Northern Sri Lanka and to assess their effects on the organic carbon fractions. The result will help to understand the behavior of soils in the tropics and manage them effectively.

Scientific Expertise: Professor S.A. Kulasooriya

Project Staff: **K. Mohanan, M.M.S.N. Premathileka, Kumari Rajapaksha**

Research Group

7.1.1.1 Development of biofilms or co-cultures for ethanol production from lignocellulosic materials

K.Mohanan, R.R. Ratnayake, S.A. Kulasooriya

Biofuel Research Project, Institute of Fundamental Studies, Kandy

Introduction

Lignocellulosic materials can be used as feedstock for ethanol production through enzymatic conversion. Reduction of expensive pre-treatment steps is needed to make the process commercially viable[1]. To this end, development of more efficient methods of enzymatic conversion will be essential.

Objectives

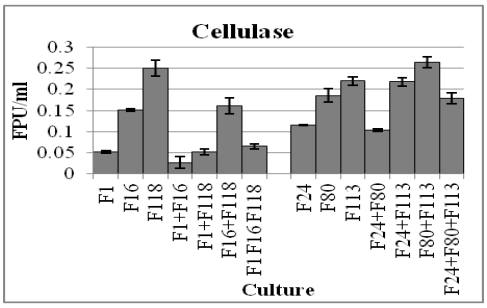
The aim of the project is to develop microbial biofilms or co-cultures which can efficiently degrade lignocellulosic materials and isolate efficient yeast strains for fermentation. The objectives were:

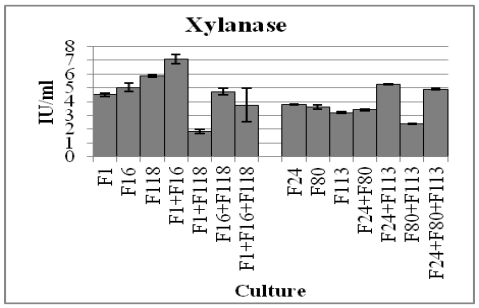
(1) Measuring the cellulase and xylanase activities of enzymes from fungal co-cultures.
(2) Measurement of the degradation of *E. crassipes* with enzymes from co-cultures.
(3) Isolation of yeast strains for fermentation of sugars.
(4) Isolation of efficient aerobic cellulolytic bacteria to form fungal-bacterial biofilms.

Results

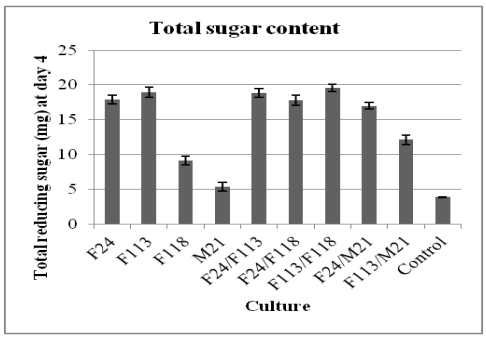
Four strains of *Trichoderma* sp (F1, F16, F80 and F118), a strain of *Penicillium sp* (F24) and an unidentified fungal strain (F113) were selected for co-culture. The fungi were divided into two groups and co-cultures were made in all possible combinations within each group. The cellulase and xylanase

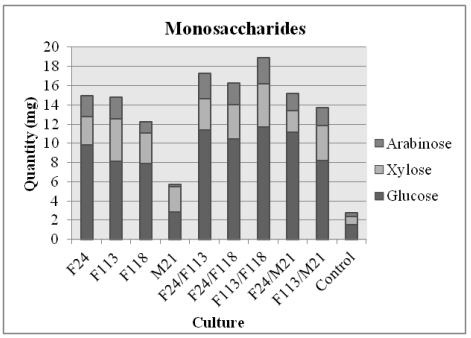
activities of the mono and co-cultures are shown in the Figures below. The cellulase activities of the co-cultures were either significantly lower or not significantly different compared to the corresponding monocultures. The co-cultures F24/F113 and F24/F80/F113 showed significantly higher xylanase activities compared to the corresponding monocultures (α=0.05)





The total reducing sugar content and monosaccharides after 4 days of degradation of 200 mg of powdered *E. crassipes* with enzymes from selected mono and co-cultures are shown below. The co-cultures of F118 (*Trichoderma* sp) showed significantly higher activity compared to F118 alone. Other co-cultures didn't show significantly higher activity. The highest amount of total sugar (19.6 mg) was obtained with the co-culture F113/F118.





7.1.1.2 Biodegradation of kitchen waste by using cellulolytic microorganisms

M. Kasinathar[1], M. Kathirgamanathan[2], R.R. Ratnayake[*2], N. Gnanavelrajah[1]

[1]Faculty of Agriculture, University of Jaffna, Jaffna, [2]Biofuel Research Project, Institute of Fundamental Studies, Kandy

Introduction

Biofuel production from kitchen waste can alleviate the problem of waste disposal and partially fulfill energy needs. It would involve enzymatic saccharification of polysaccharides followed by fermentation to produce the desired biofuel. The feasibility of such a process depends on the efficiency and cost of the enzymes used. The present study was aimed at isolating efficient strains of cellulose degrading micro-organisms from the environment and studying the effectiveness of crude enzymes from selected strains.

Objectives

Study the degradation of kitchen waste by crude enzymes extracted from selected strains of fungi and bacteria

Results

Thirty three fungal strains were isolated and six strains, belonging to the genera *Trichoderma*, *Aspergillus*, *Penicillium* and an unidentified genus, were selected fordegradation of kitchen waste. Significant quantities of sugars were released by the degradation of both types of substrates for all cultures. The highest amount of sugars released after 7 days was observed with two monocultures of *Penicillium* sp.(59.6 mg and 55.8mg) and a co-culture of a *Penicillium* sp. and the unidentified fungus (58 mg) from fresh kitchen waste (Fig. 01). The enzymatic degradation of kitchen waste released significantamounts of sugars. Therefore, kitchen waste could possibly be used as a raw material for biofuel production. Further studiesto quantify the different types of sugars that are released by the degradation are needed to further assess the feasibility of biofuel production from kitchen waste.

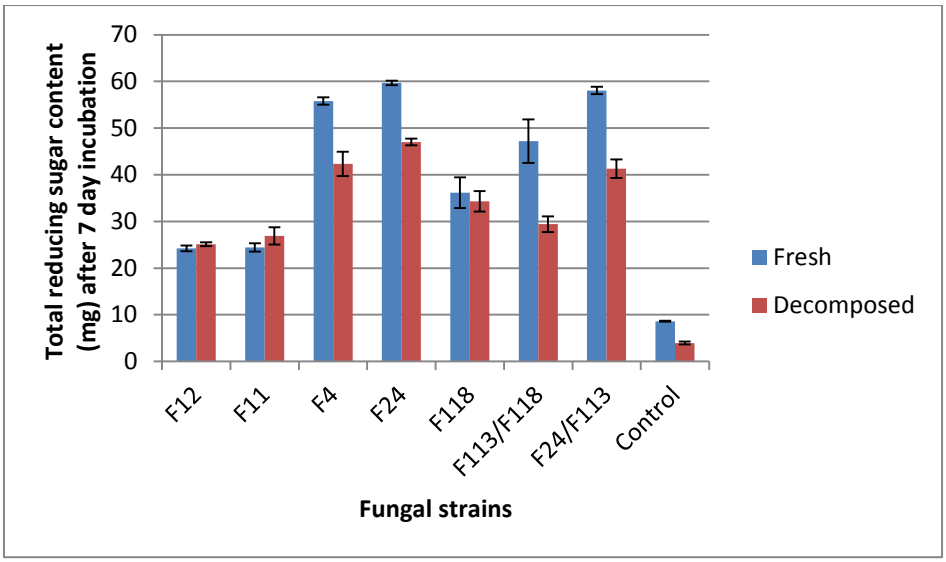


Fig. 01: Sugar yield by selected cultures after 7 day incubation

1. Variation of microbial community along a chronosequence of age in *Eucalyptus grandis* forest plantation

M.M.S.N. Premetilake[1] , R.R. Ratnayake[2], S.A. Kulasooriya[2], G.A.D. Perera[3]

[1]Uva Wellassa University, Badulla, [2]Biofuel Research Project, Institute of Fundamental Studies, Kandy, [3]University of Peradeniya, Peradeniya

Introduction

Forests cover about 31 % of total land area in the world and from it plantation forests is about 1.39 x 10^8 ha and it is expanding at a higher rate (Global forest resource assessment, 2010). In Sri Lanka 1 % of total land area is covered by plantation forests and 20% of that is represented by Eucalyptus plantations (Bandarathilake, 1996). But in Sri Lanka these plantation forests are establish most of the time in nutrient poor land areas which may leads to poor yields. And also soil under Eucalyptus plantations is considered to be degraded due to nutrient depletion due to their higher growth rate and plant diversity reduction. Moreover Eucalyptus commonly produces litter with low nutrient concentrations which decomposes slowly especially at the early stage of the litter decomposition. And

usually after the initial estate no fertilizer addition was carried out in Sri Lankan plantation forests. So the soils in these plantation forests have very low amount of nutrients. So the cycling of those limited nutrients is crucial for a betteryield. The most important component that is responsible for nutrient cycling is microbial community in the soil. But many factors change chemical, physical composition of plantation forest soil which affect its microbial community. One is stand age. The understanding of potential changes in microbial community with age of the plantation forest is important for the sustainable management and restoration of Eucalyptus plantation soils. However, the studies on the soil microbial community composition associated with Eucalyptus are not well documented. So the purpose of this research is to study the variation of microbial community composition with stand age of the *Eucalyptus grandis* plantation forest.*Eucalyptus grandis* forest plantation sites of four different age groups (Age of 5, 11, 20 and 28 yrs.), but with similar geological characteristics were selected. As before afforestation all these sites were Patana grasslands to compare the results adjacent Patana grass land, a tea estate and a natural forest in the same area were selected.

Objectives

Study the variation of microbial community composition with stand age of the *Eucalyptus grandis* plantation forest.

Results

Compared with tea estate, abandon site and natural forest, the *Eucalyptus p*lantation soil had very low amount of fungi population (Fig.01). From forest plantations, the oldest, 30 years old site had the highe0st number of fungi (953 ± 122 MPN $^{g-1}$). The lowest was recorded in 22 years old site (113 ± 52 MPN g^{-1}). And the fungal populations in Eucalyptus plantations were affected by the stand age (One way, ANOVA:$p = 0.000$;$R^2 = 98.44$ %). But there were no significant differences between bacterial populations with in *Eucalyptus* plantations ($p > 0.05$) and with other studied sites as well ($p>0.05$).Fungi to bacteria population ratios (F: B) for the studied sites are shown in Table 01. All the values are less than 1, indicating all the study sites are bacterial dominant sites. The F:B ratio was significantly affected by age of the *Eucalyptus* plantation (One way ANOVA; $p <0.05$, $R^2 = 88.95$ %) (Table 01).

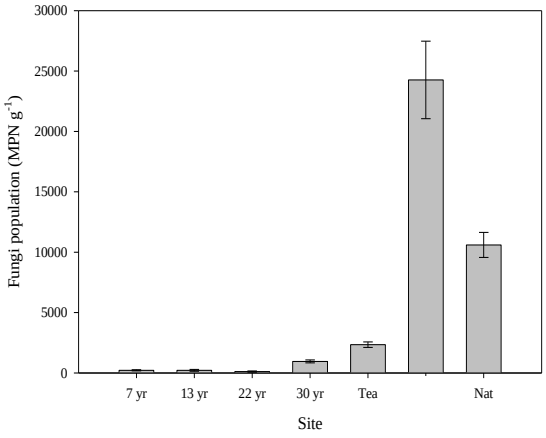


Figure 01: Variation fungal population between sites

Table 01: F:B ratios of studied sites

SITE	F:B	
7 yr forest plantation	$3.0 \times 10^{-4} \pm 4.0 \times 10^{-6}$	b
12 yr forest plantation	$3.4 \times 10^{-4} \pm 2.2 \times 10^{-5}$	b
22 yr forest plantation	$1.1 \times 10^{-4} \pm 7.7 \times 10^{-5}$	b
30 yr forest plantation	$9.1 \times 10^{-4} \pm 1.1 \times 10^{-4}$	ab
Tea estate	$3.3 \times 10^{-3} \pm 6.0 \times 10^{-6}$	b
Patana grass land	$3.4 \times 10^{-2} \pm 2.7 \times 10^{-5}$	a
Natural forest	$9.2 \times 10^{-3} \pm 1.0 \times 10^{-4}$	ab

7.1.1.4 Carbon fractions and nutrient status of soils in Iranamadu irrigation command area, Kilinochchi

S. Raguraj[1], R.R. Ratnayake[*2], N.Gnanavelrajah[1]

[1]Faculty of Agriculture, University of Jaffna, Jaffna, [2]Biofuel Research Project, Institute of Fundamental Studies, Kandy

Introduction

Kilinochchi district comes under dry zone of Sri Lanka and has a high potential for agriculture. Iranamadhu tank is the largest tank in Kilinochchi which supplies water for the farming activities in dry season. The total command area of Iranamadhu is 8455 ha. The area has important potential for paddy cultivation and subsidiary crops such as chilli, onion, groundnut, green gram etc. In the upland perennial crops include mango, jackfruit, coconut, etc. A declining trend in crop yields has been reported by farmers in this area. Though Kilinochchi district fall under dryzone, lands under Iranamadu command area are supplied with irrigation water. Hence, foremost limiting factor for

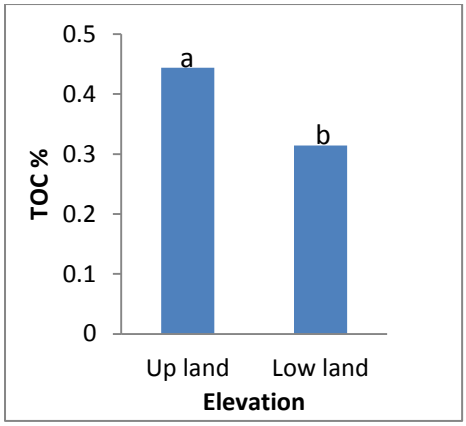
crop production in this area is probably infertility of soils. To get high yield continuously, nutrients in the soil should be available at optimum level. Soil organic matter plays a crucial role in the availability of both macro and micronutrients in soils mainly through the chelating effects. Therefore, knowledge about carbon provides valuable information in managing agricultural soils.

Objective

Assessment of total carbon and its carbon fractions in comparison with elevation, land use and depth wise.

Result

Total organic carbon (TOC) significantly varied with elevation (upland and lowland) and depth wise (0-20 cm and 20-40 cm), and ranged between 0.07 - 1.02 %. Upland soils had higher total organic carbon than lowland soils (Figure 1). In general top layer (0-20cm) had asignificantly higher TOC compared with deeper layer (20-40 cm) (Figure 2). Soil fertility level in terms of TOC ranged between medium to low (0.4 – 0.8%).



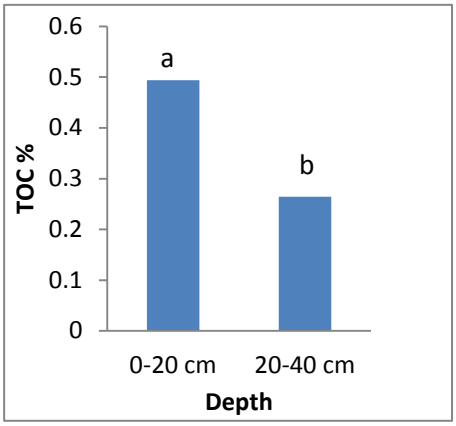
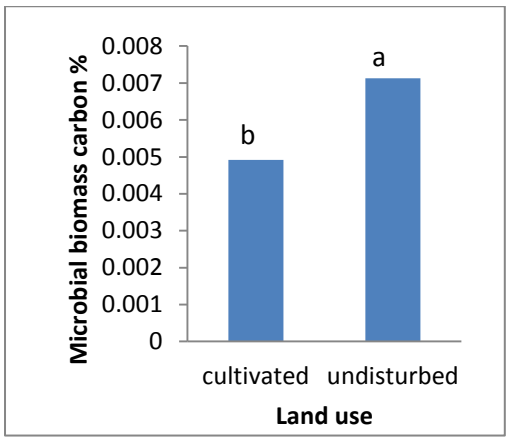


Figure 1: TOC with elevation

Figure 2: TOC in different depths

Microbial biomass content ranged from 0.001 to 0.016% and significantly differed with land use and depth wise. Top layer had higher amount (average – 0.009%) than deeper layer (average – 0.04 %).



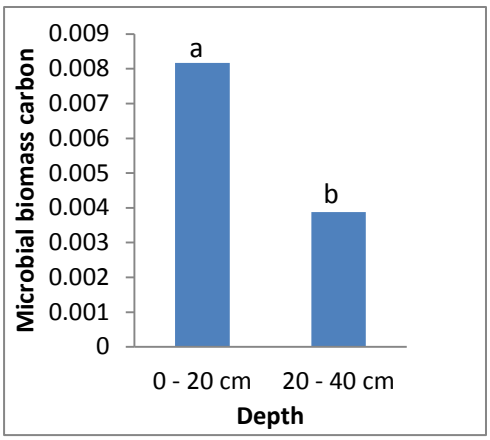
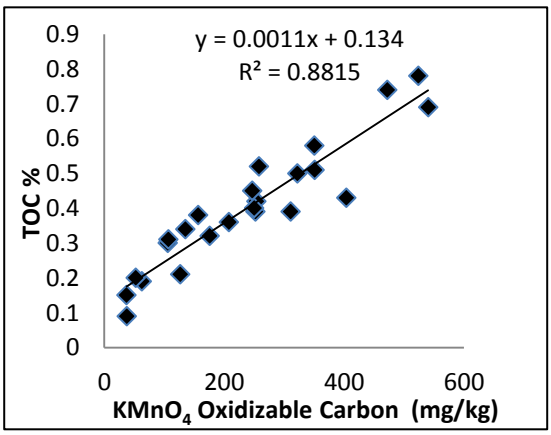


Figure 3: MBC in different depths

Figure 4: MBC in different land uses

Relationships of oxidizable carbon with other carbon fractions



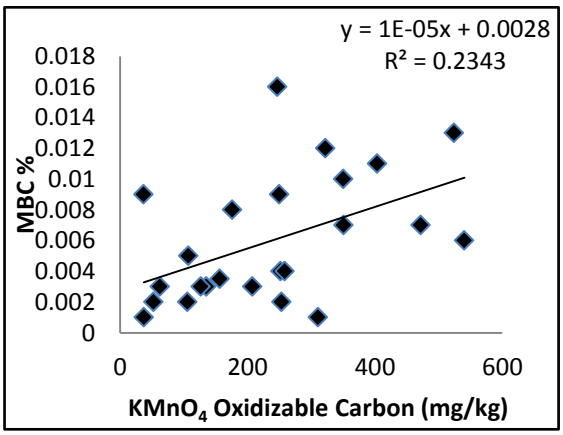


Figure 5:Relationships of Permanganate oxidizable carbon with other C fractions

Table 2: Correlations between carbon fractions

		MBC	TOC	WSC
POC	Pearson Correlation	0.484*	0.939**	-0.101
	Sig. (2-tailed)	0.017	0.00	0.637
	N	24	24	24

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed). POC – Permanganate Oxidizable Carbon, MBC – Microbial Biomass Carbon, TOC – Total Organic carbon

The experiment showed that, carbon sequestration potential was higher in upland areas of uncultivated soils compared to lowland soils. The outcome of this study will provides valuable information in managing agricultural soils in Iranamadu irrigation command area.

Collaborators

1. Ms. Manori Gunaratne, Sustainability Manager, Finlays Tea Estates Lanka (Pvt) Ltd.
2. Dr. N. Gnanavelrajah, Faculty of Agriculture, University of Jaffna

Human Resource Development

Registered for Ph.D and M.Phil.

1. M.M.S.N. Premathileka registered for Ph.D. at PGIS, University of Peradeniya
   Title: *Soil carbon sequestration in forest plantations of Sri Lanka.*
2. W.A.D.D. Wasalamuni registered for M.Phil. at PGIS, University of Peradeniya
   Title: *Potential of soil carbon sequestration inhome gardens of Sri Lanka.*
3. K. Mohanan registered for M.Phil., at PGIS, University of Peradeniya
   Title: *Development of microbial strains and biofilms for efficient production of ethanol from cellulosic materials*

Research students (M.Sc., B.Sc.) and Trainees

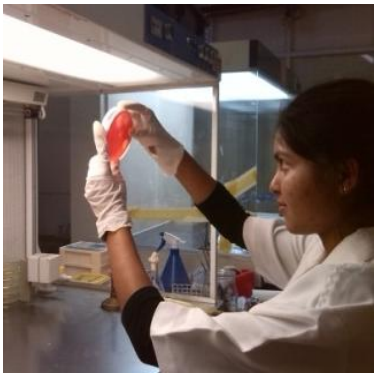
1. K. Mathaniga (B.Sc. Student – University of Jaffna)
2. S. Raguraj (B.Sc. Student – University of Jaffna)
3. R.S.N. Kulathunga (B.Sc. Student – Rajarata University of Sri Lanka)
4. Sachni Amunugama (B.Sc. Student – University of Ruhuna)
5. Chanaka Perera (Aquinas University College)
6. Chaminda Alahakoon (Pre university research student)
7. Supun Galappaththi (Pre university research student)
8. Pavithra Madamarandawala (Pre university research student)

Progress of our Research Projects









7.1.2 CONDENSED MATTER PHYSICS AND SOLID STATE CHEMISTRY

Project Leaders: **Prof. M.A.K.L. Dissanayake** *(Research Professor)*
Dr. G.K.R. Senadeera (*Visiting Associate Research Professor*)

Description of the Projects

During 2013, the research activities of the Condensed Matter Physics were focused on (a) Efficiency enhancement of dye sensitized solar cells based on polymer gel type electrolytes and nanofibre membrane electrolytes (b) Development of polymer nanofibre membranes for removal of arsenic (As) from drinking water and (c) Optimization of CdS films towards fabrication of efficient CdS/CdTe photovoltaic solar cells.

Dye sensitized solar cells with PEO: PC: $Pr_4N^+I^-$ + *x* KI: I_2 as the gel electrolyte were fabricated using samples with different weight ratios of KI and $Pr_4N^+I^-$mixed iodide system and the highest efficiency was observed for the composition with 75 wt% of KI and 25 wt% of $Pr_4N^+I^-$. This type of efficiency enhancement in dye sensitized solar cells due to the mixed cation effect was reported by our group for the first time and appears to be generally valid for many DSSC systems.In order to test the applicability ofelectrospun polymer nanofibre based electrolytes in dye sensitized solar cells, poly(acrylonitrile) (PAN) nanofibers with diameters in the range of 800-900 nm soaked in a liquid electrolyte were used as the electrolyte in dye sensitized solar cells and their photovoltaic characteristics were compared with the conventional liquid electrolyte and gel electrolyte. It was observed that DSSC with optimum nanofibremembrane thickness of 9.14 µm showed the highest light-to-electricity conversion efficiency of 5.2%. We have successfully synthesized bio-compatible polymer nanofibres using the electrospinning technique incorporating TiO_2 and Fe_2O_3 in order to develop a nanofibre medium to remove arsenic (As) from drinking water.CdS thin films made by chemical bath deposition technique have been characterized by UV-VIS absorption measurements in order to obtain the optimum band gap as a function of film thickness to be used in CdS/CdTe solar cells.

Research activities of the Solid State Chemistry were focused on (a) Synthesis of gel electrolytes for magnesium rechargeable batteries and sodium batteries and (b) synthesis and characterization of solid and gel polymer electrolytes for possible applications in Electrochromic displays (smart windows).

Alternatives to the current lithium-ion-based batteries for electric cars and other electrical devices are at the forefront of the battery research agenda. Manufacturers want to build batteries with higher capacity and longer life, and to achieve this, new research efforts must be focused on developing alternative batteries. One promising battery material is based on Mg anode and Mg^{++} ion conducting electrolytes. Magnesium is more dense than lithium, it is safer, and the magnesium ion carries a two-electron charge, giving it potential as a more efficient energy source. Magnesium has a high volumetric capacity, which could mean more battery power in a smaller space. During 2013, our research group has successfully developed novel Mg^{++} ion conducting polymer electrolytes and fabricated novel rechargeable Mg batteries with relatively high capacity.

Electrochromic devices (ECDs) such as displays or smart windows are able to change light transmission properties in response to an applied voltage and thus allow control over the amount of light and heat passing through. An ECD comprise of an electrochromic electrode separated by an electrolyte from a counter electrode. Due to many problems associated with liquid electrolyte based ECDs, there is a need to develop alternative electrolyte materials for ECDs. During 2013, our group has successfully developed a TiO_2 based ECD (Electrochromic Smart window) with Chitosan Gel polymer Electrolyte.

Collaborators

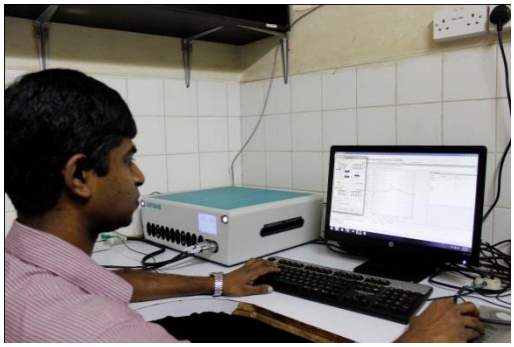
1. Dr. V.A. Seneviratne, Department of Physics, University of Peradeniya
2. Prof. B.-E. Mellander, Chalmers University of Technology, Gothenburg, Sweden
3. Prof. S. Sivananthan, University of Illinois at Chicago, USA & Sivananthan Laboratories, Inc. Bolingbrook, IL, USA
4. Prof. I.M. Dharmadasa, Sheffield Hallam University, UK
5. Prof. Arof Karim, Center for Solid State Science, University of Malaya, Malaysia
6. Prof. Piyasiri Ekanayake, Faculty of Science, University of Brunei Darussalam
7. Dr. T.M.W.J. Bandara, Department of Physical Science, Rajarata University
8. Prof. P. Ravirajan, Department of Physics, University of Jaffna

Research Assistants

1. Mr. C.A. Thotawatthage (Research Assistant)
2. Ms. W.N.S. Rupasinghe (Research Assistant)
3. Ms. S.L. Jayaratne (Research Assistant)
4. Ms. H.K.D.W.M.N/R. Divarathne (NRC Research Student)
5. Mr. P.M.P.C Ekanayake (NRC Research Student)
6. Ms. H.M.N. Sarangika (Prob. Lecturer from Sabaragamuwa University)
7. Ms. K. Paramanathan (NSF Research Student)

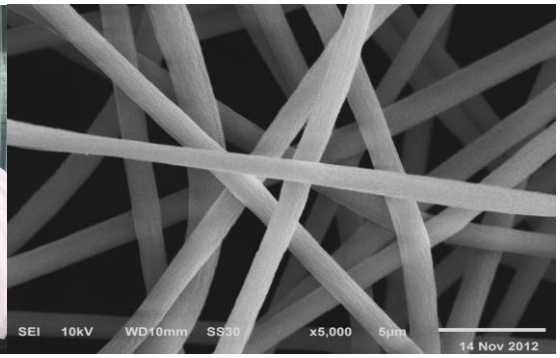
Members of the Condensed Matter Physics and Solid State Chemistry Research Groups of the Institute of Fundamental Studies (IFS), Kandy (2013)

(Absent: Ms. W.N.S. Rupasinghe, Ms.S.L. Jayaratne, H.K.D.W.M.N.R. Divarathne)



Research students making TiO_2 photoanodes (Left) and measuring ionic conductivity of polymer electrolytes (right)

Research students making Electrochromic Devices (Left) and measuring solar cell I-V characteristics (right)



IFS Nano Team (Left) and electrospun polymer nanofibres used for nanofilters (right)

7.1.2.1 Efficiency Enhancement by Binary Iodide Salts and Nanofiller Effect in Polyethylene Oxide (PEO) Based Dye Sensitized Solar Cells

M.A.K.L. Dissanayake[1,2,*], W.N.S. Rupasinghe[1,3], V.A. Seneviratne[2], C.A. Thotawatthage[1], G.K.R. Senadeera[1,4]

[1]Condensed Matter Physics and Solid State Chemistry Project, Institute of Fundamental Studies, Kandy, [2]Department of Physics, University of Peradeniya, Peradeniya, [3]Postgraduate Institute of Science, University of Peradeniya, Peradeniya, [4]Department of Physics, The Open University of Sri Lanka, Nugegoda

Efficiency enhancement by binary iodide salts and nanofiller effect in polyethylene oxide (PEO) based dye sensitized solar cells (DSSCs) have been achieved. Most of the reported DSSCs have used

only one ionic salt, generally an iodide salt, in the electrolyte which contains either a smaller or a larger cation. Both cation types have their own advantages. In this work, we have demonstrated that, in PEO electrolyte based DSSCs, the combined effect of using a smaller cation such as K^+ along with a larger cation, such as Pr_4N^+ to provide the iodide ion conductivity enhances the solar cell efficiency compared to the efficiency obtained when they are used separately.

The incorporation of inorganic nano fillers into the polymer electrolyte increases the solar cell efficiency. The high crystallinity of PEO leads to a low ionic conductivity which directly give rise to a low short circuit current density and hence a low efficiency. The incorporation of the inorganic nano filler, TiO_2 increases the amorphous phase content in PEO which enhances the ionic conductivity, short circuit current density and hence the solar cell efficiency.

7.1.2.2 Quasi-Solid State Dye-Sensitized Solar Cells Based on Electrospun Polyacrylonitrile (PAN) Nanofibre Membrane Electrolyte

M.A.K.L. Dissanayake[1,4,5], H.K.D.W.M.N.R. Divarathne[1,5], C.A. Thotawatthage[1], C.B. Dissanayake[1], G.K.R. Senadeera[1,2], B.M.R. Bandara[3]

[1]Condensed Matter Physics and Solid State Chemistry Project, Institute of Fundamental Studies, Kandy, [2]Department of Physics, Open University of Sri Lanka, Nugegoda, [3]Department of Chemistry, University of Peradeniya, Peradeniya, [4]Department of Physics, University of Peradeniya, Peradeniya, [5]Postgraduate Institute of Science, University of Peradeniya, Peradeniya

Dye Sensitized Solar Cells (DSSCs) based on electrospun nanofibre membrane electrolytes offer several advantages over liquid electrolyte based solar cells. Nanofibre membranes having different thicknesses were prepared by electrospinning on platinum electrodes from a 11 wt% solution of polyacrylonitrile (PAN) in N,N-dimethylformamide (DMF) at an applied voltage of 8 kV. The membranes were then activated by immersing in a solution containing potassium iodide (KI) (0.06 g), propylene carbonate (PC) (0.8 g) and iodine (I_2) (0.0092 g) for 30 minutes to obtain membrane electrolytes with different thicknesses. These nanofibre membrane electrolytes were used to fabricate quasi-solid state (gel) DSSCs and the performance of these solar cells were compared with DSSCs fabricated with liquid electrolyte (KI:PC:I_2) and conventional PAN based gel electrolyte (PAN:KI:PC:I_2). DSSC with membrane electrolyte of thickness 9.14 µm showed the highest light-to-electricity conversion efficiency of 5.2% whereas an identical cell based on corresponding liquid electrolyte showed an efficiency of 5.3%. The open circuit voltage (V_{OC}), short circuit current density (J_{Sc}) and fill factor for thesolar cell based on this electrolyte was 0.67 V, 13.31 mA cm^{-2} and 59% respectively at an incident light intensity of 1000 W m^{-2} with a 1.5 AM filter.

7.1.2.3 Arsenic Removal from Contaminated Water by TiO_2 and Fe_2O_3 Incorporated Polymer Nanofibre Membrane Media

M.A.K.L. Dissanayake[1,3], C.B. Dissanayake[1], P.M.P.C. Ekanayake[1,3], G.K.R. Senadeera[1,5], B.M.R. Bandara[2,3], S.R. Weerasooriya[4]

[1]Condensed Matter Physics and Solid State Chemistry Project, Institute of Fundamental Studies, Kandy,[2] Department of Chemistry, University of Peradeniya, [3]Postgraduate Institute of Science, University of Peradeniya,[4] Faculty of Agriculture, University of Peradeniya,[5]Open University of Sri Lanka, Polgolla Campus, Polgolla

Unique physical properties of polymer nanofibres make them promising candidates for filter media in air and water filtration. Polymer nanofibres can be produced by electrospinning with a diameter of 20-

1000 nm. They have very high specific surface area, small diameter and large porosity. Polymer nanofibre membranes prepared by electrospinning technique incorporating TiO_2 (P25) and γ-Fe_2O_3 (Sigma-Aldrich) has been used successfully to remove arsenic (As III/As V) from water. Nanofibre membranes were soaked in arsenic solution (concentration, 25 ppb) for known time durations and the remaining arsenic concentrations were measured using Atomic Absorption Spectroscopy (AAS). A significant reduction in arsenic concentration was observed due to theexcellent photocatalytic oxidation property of TiO_2 and high adsorption capacity and magnetic property of γ-Fe_2O_3.

7.1.2.4 Optical Properties of Cds Film Grown on FTO Substrate by CBD Method

K. Paramanathan[1, 2, *], M.A.K.L. Dissanayake[1, 2],G. K.R. Senadeera[1, 3], C.A. Thotawatthage[1], P. Ravirajan[4]

[1]Condensed Matter Physics and Solid State Chemistry Project, Institute of Fundamental Studies, Kandy, [2]Postgraduate Institute of Science, University of Peradeniya, Peradeniya, [3] Department of Physics, the Open University of Sri Lanka, Polgolla Campus, [4]Department of Physics, University of Jaffna, Jaffna

Thin film CdS/CdTe solar cells have emerged as a cost effective and high efficiency alternative to expensive silicon solar cells. Optimizing the growth process of CdS films is important in order to further enhance the efficiency of these solar cells. Out of several different methods available for preparing CdS thin films, chemical bath deposition (CBD) technique appears to be the most widely used method due its simplicity, low cost, reproducibility and the possibility of scaling up for commercial production. The aim of this work is to study the optical properties of CdS thin films prepared by CBD method under different deposition times. Transparent, homogenous cadmium sulfide (CdS) thin films were deposited by chemical bath deposition (CBD) technique on Florine doped Tin Oxide (FTO) substrates by varying the deposition time from 10 to 60 minutes in a bath containing cadmium chloride, ammonium chloride, ammonium hydroxide and thiourea and the bath temperature was maintained at 65 ^{0}C. With that, 60 minutes deposited CdS thin films were annealed under N_2 gas with 100 and 200 °C. The effect of the film thickness on optical absorbance was studied by measuring the absorbance from 190 nm to 1100 nm using a UV VIS- 2450 (SHIMADZU) spectrophotometer. From the optical absorption, the energy band gap values of CdS thin films were determine to be 2.47, 2.44, 2.41, 2.35, 2.31 and 2.27 eV for the deposition times of 10 to 60 minutes. With increasing thickness (deposition time) of the CdS films, the optical energy band gap values of CdS thin films were decreased. This could be due to the increase in particle size with increase in the deposition time and the increases of density of localized state in the conduction band. Higher annealing temperatures cause a reduction in optical band gap energy values for CdS thin films. During the annealing process, atoms rearrange to more energetically favourable positions in the valence band. This way, the photo-current can be increased due to the longer mean free path of electrons, so that less energy is sufficient for an electron to jump to the conduction band.

7.1.2.5 Use of Carbon Embedded TiO_2 as Cathode Material In Rechargeable Mg Batteries With PEO Based Gel Electrolyte

H.N.M. Sarangika[1, 2, 5*], W.A.R.B. Weerasekera[3], G.K.R. Senadeera[1, 3], M.A.K.L. Dissanayake[1,4,5], C. A. Thotawatthage[1], V.A. Seneviratne[4]

[1]Condensed Matter Physics and Solid State Chemistry Project, Institute of Fundamental Studies, Kandy.[2]Department of Physics, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka,[3] Department of Physics, Open University of Sri Lanka, Nugegoda.[4] Department of Physics, University of Peradeniya, Peradeniya, Postgraduate Institute of Science, University of Peradeniya, Peradeniya

In the past few years there has been an increasing interest on research and development of solid state polymeric lithium batteries. However, due to some problems such as the growth of a passive layer on lithium anode, high reactivity of lithium metal, limited availability as a raw material etc., scientists have realized that magnesium batteries would be one of the best alternatives to Li batteries. In this context, it is worthy to mention that magnesium is much more stable and less reactive than lithium towards the moisture and air. In addition, most of the these Li batteries, either employ MnO_2 based or V_2O_5 based cathodes due to their superior performances but neglecting the long term availability and the preparation cost of these materials. Therefore, by considering both these factors, in this study we have explored the possibilities of using of low cost TiO_2 as the cathode martial in magnesium batteries fabricated with Mg^{++} ion conducting, quasi solid (gel) polymeric electrolyte based on polyethylene oxide (PEO) as the host matrix. In order to obtain quasi solid polymeric electrolyte having high Mg^{++} ion conductivity with appreciably good mechanical properties, various compositions of PEO based polymer electrolytes were prepared using appropriate amount of PEO, Magnesium Trifluoromethanesulfonate $Mg(CF_3SO_3)_2$, Ethylene Carbonate (EC) and Propylene Carbonate (PC). Electrochemical stability of the electrolyte was characterized by Cyclic Voltammetry (CV). The best ionic conductivity of the electrolyte estimated by the complex impedance measurements was in the order of 2.52×10^{-3} S/cm at room temperature for the composition of PEO (12.20 wt%), (14.6 wt%), EC (36.6 wt%) , PC (36.6 wt%). The ionic conductivity of this electrolyte composition increased with the temperature following the usual Arrhenius behavior and showed a value of 3.44×10^{-3} S/cm at 60 ^oC. Batteries with cell configuration Mg/PEO:EC:PC:/TiO_2-C were fabricated, by varying the amount of carbon in the cathode until it gives the best battery performance with highest open circuit voltage and the short circuit current density. This cell exhibited a discharge capacity of 370 mAh/g and 1.85 V open circuit voltage with reasonably good cycling capacity.

7.1.2.6 Novel Quasi Solid State Electrochromic Smart Windows Based on TiO_2 And SnO_2 Electrodes With PMMA Gel Electrolyte

H.N.M. Sarangika[1,2,3], G.K.R. Senadeera[1,4], C. A. Thotawatthage[1], M.A.K.L.Dissanayake[1,2]

[1]Condensed Matter Physics and Solid State Chemistry Project, Institute of Fundamental Studies, Kandy, [2]Postgraduate Institute of Science, University of Peradeniya, Peradeniya, [3]Department of Physical Sciences and Technology, Sabaragamuwa University of Sri Lanka, [4]Department of Physics, The Open University of Sri Lanka

In recent past electrochromic devices have attracted much attention due to their potential practical applications in everyday life with low cost power consumptions. However almost all the reported studies on these devices were concentrated with the devices comprising with expensive WO_3 as the active material and CeO_2 as the counter electrode. Further, preparation techniques of these materials are also not very much straight forward for lots of application.

Therefore, in this study we have explored the possibility of using TiO_2 as the electrochromic material and at the same time to replace the expensive CeO_2 with SnO_2 in these devices by fabricating stable and efficient electrochromic devices. The devices with the dimensions, 2.1x1.4 cm^2 comprising the configuration (FTO) glass/TiO_2/polymer electrolyte / SnO_2 were assembled and their properties tested. The polymeric quasi solid stateelectrolyte employed was based on Poly (methyl methacrylate) (PMMA) electrolyte containing Li^+ ions. Structural, electrochemical and optical properties of the electrolyte and ECDs were characterized by X-ray diffraction (XRD) analysis, cyclic voltammetry (CV), ultraviolet-visible spectrophotometry. The structure of the electrolyte is X-ray amorphous. Its ionic conductivity was in the order of $1.5x10^{-4}$ S/cm with lithium concentration of 0.5 g/7.5 ml. This value increased with the temperature and followed the Arrhenius law with an activation energy of 49.5 kJ/mol. Prepared ECDs showed reversible dark blue coloration and long term stability with more than 1000 switching cycles. The device changed its transmission between 64% (bleached state) and 0.26% (colored state) at 600 nm. The preliminary studies on the stability of the devices have been tested by cycling them between the colored and bleached states at potentials between +4.0V and -0.25 V (90 s), respectively, and after the potential stepping of 1000 times, no loss on the transmittance response was observed.

Human Resource Development

Ph.D, M.Phil., M.Sc. students, undergraduate students trained during 2013 with their affiliations; completed and passed out during 2013

Postgraduate students trained/supervised by Prof. M.A.K.L. Dissanayake and Dr. G.K.R. Senadeera during 2013:

1. Ms. W.N.S. Rupasinghe, Research Assistant, registered for M.Phil., PGIS, University of Peradeniya, (thesis submitted in November 2013).
   Thesis Title: *Synthesis, characterization and applications of polyethylene oxide (PEO) based nano-composite polymer electrolytes and their applications in dye-sensitized solar cells and other devices.*

2. Ms. S.L. Jayaratne, Research Assistant, registered for M.Phil., PGIS, University of Peradeniya, (thesis under preparation).
   Title: *Efficiency Enhancement in Dye – Sensitized Solar Cells with blend polymer electrolytes*

3. Ms. H.K.D.W.M.N/R. Divarathne, (NRC Research Student, registered for M.Phil., PGIS, University of Peradeniya, (thesis under preparation).
   Title: *Dye sensitized solar cells with polymer nanofibre based electrolytes and TiO_2 nanofiber based photoanode.*

4. Mr. P.M.P.C Ekanayake, (NRC Research Student, registered for M.Phil., PGIS, University of Peradeniya, (training continued).
   Title: *Synthesis of polymer nanofibers and design and testing of a polymer nanofiber, antimicrobial water filter.*

5. Ms. Ms. H.M.N. Sarangika (Probationary Lecturer, Sabaragamuwa University, registered for M.Phil., PGIS, University of Peradeniya, (training continued).
   Title: *Development of novel quasi solid (gel) polymer electrolytes and their applications in electrochemical power sources.*

6. Ms. W.J.M.J.S.R.Jayasundara (Rajarata University, M.Phil., (completed), PGIS, University of Peradeniya)
   Title: *Effect of cations on the performance of dye sensitized solar cells using polyacrylonitrile based plasticized polymer electrolytes containing quaternary Ammonium iodides.*

7. Cmdr. C.I.F. Attanayake, registered for PhD, Moratuwa University of Sri Lanka , (training continued).
   Title: *Design and Development of Dye – Sensitized Organic Semiconductor Based Photo Electric System Utilizing Nanotechnology For Low Cost And Efficient Conversion Of Solar Energy To Electricity.*

8. Mr. T.R.C.K. Wijayaratna, registered for M.Phil., Open University of Sri Lanka (former Research Assistant at IFS, Kandy, (thesis completed).
   Title: *Metal nanoparticle impregnable semiconductor nanostructures: Plasmon effects and applications in solar cells.*

9. Ms. K. Paramananthan (NSF Research Student) registered for M.Phil., PGIS, University of Peradeniya, training continued.
   Title: *Optimization of the growth process of cadmium sulfide (CdS) semiconductor thin films for efficiency enhancement in CdS/CdTe solar cells*

10. Mr. R.I.C. Niroshan Karunaratne, registered for M.Sc. (Physics of Materials), PGIS, University of Peradeniya, completed his research project on sodium ion batteries at the IFS during 2013.
    Title: *Synthesis and Characterization of Sodium ion Rechargeable Energy Storage Batteries based on* $Na_2Ti_3O_7$ *as Anode with respect to* $Na_{0.85}Li_{0.17}Ni_{0.21}Mn_{0.64}O$ *and* $NaMn_2O_3$ *are Cathode materials.*

Undergraduate students trained during 2013

1. Mr. W.A.R.B. Weerasekera (From OUSL, completed his undergraduate research project, June-December 2013)
2. Mr. M.R.M.E.M. Ratnayake, (From RUSL, completed his undergraduate project, January-June 2013)
3. Mr. Y.M.C.D. Jayathilaka (From Wayamba University, completed a part of his research for the M.Phil. degree, 2013)
4. Ms. Mahisha Amarasinghe (From University of Peradeniya completed her undergraduate research project)

7.1.3 GEOTHERMAL ENERGY

Project Leader: Dr. N.D. Subasinghe *(Senior Research Fellow)*

Geothermal Resource Mapping in Sri Lanka

Despite its location in a shield zone, away from the major plate boundaries where high enthalpy geothermal activities occur, Sri Lanka is gifted with a number of thermal springs, scattered loosely along a belt running from south to east coast. This belt loosely follows the Highland-Vijayan lithological boundary. While some of these thermal springs are well known, others are known only to a small number of people outside the local area. Despite some attempts to characterise few individual thermal springs, no complete information on the geothermal resources of Sri Lanka is available. Geothermal resource mapping project was started with an aim to identify, map and characterise the geothermal resources in Sri Lanka.

Geophysical investigations using State-of the-art geophysical instruments were conducted at the early stages of the project. Magneto-telluric (MT) and TEM were the main geophysical techniques employed to collect data. Processing, inversion and interpretation of the geophysical data are continuing. In the mean time, geochemical and geological investigations are also conducted. Eventually, it is expected to produce a detailed map with information on geothermal resources in Sri Lanka. Further, the outcome of this project will help to understand the relationship between the Highland-Vijayan lithological boundary and the distribution of the thermal springs.

Some of the thermal springs indicate that they are originated from large depths. These springs may contain radon gas, which is usually released by the rocks in the deep earth. Radon levels in the spring waters give an indication of their origin and the depth. Therefore, as a part of the geothermal project, radon mapping project was also started with the collaboration of Atomic Energy Authority. National Institute for Radiological Sciences (NIRS) in Japan, Tokyo University and International Atomic Energy Authority provided training and passive radon detectors for this project. First batch of 50 radon detectors were installed, exposed and collected. Results indicated that Sri Lanka has relatively high amount of thorium in the soil and minerals. In addition to studying the geological aspects, radon monitoring program will help to establish the baseline for our natural radiation levels and to find out areas with hazardously high radon levels.

From Left to Right

T.B. Nimalsiri	Geothermal Project, M.Phil. Research Student
N.B. Suriyaarachchi	Geothermal Project, M.Phil. Research Student
A. Tennakoon	N.S.F. Technical Assistant
N.D. Subasinghe	Project Leader
D.R. Charles	NSF Research Assistant, M.Phil. student
S. Opatha	Senior Staff Technical Officer
B. Jayatilake	Environmental Engineering, M.Phil. Research Assistant

7.1.3.1 Study of the Near-Surface Resistivity Structure in Padiyathlawa Area Using Transient Electromagnetic Method

N.B. Suriyaarachchi, T.B. Nimalsisri, N.D. Subasinghe

Institute of Fundamental Studies, Kandy

Introduction

Sri Lanka has several hot water springs that are distributed around the Highland-Vijayan lithological boundary. The thermal spring belt along this boundary implies some heat source beneath.In 2010, a comprehensive geophysical survey was conducted around the thermal springs in Sri Lanka, employing Magnetotelluric (MT) and Transient Electromagnetic (TEM) methods. Processing and interpretation of theTEM data collected from Padiyathalawa area are presented here.

Objectives

1. Gather detailed information on the nature of the thermal springs and geothermal resources in Sri Lanka.
2. Understanding the origin of the thermal springs and their relationship to the Highland-Vijayan lithological boundary

Results

Following figures show the apparent resistivity profiles of areas around the hot springs in Padiyathalawa.

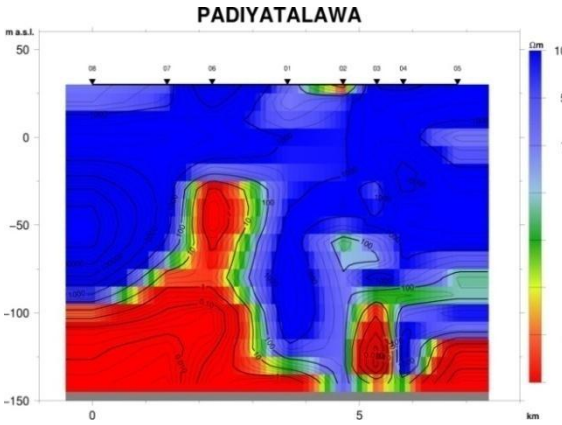


Fig. 1.Cross-section showing resistivity in hot spring area

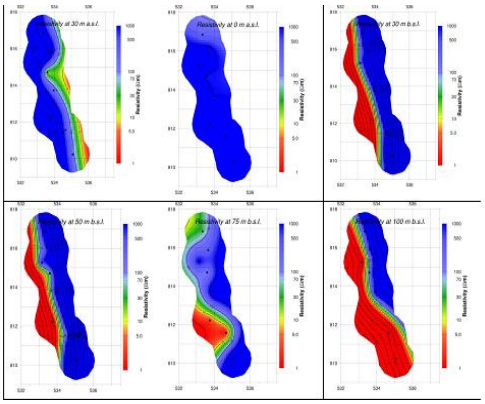


Fig. 2. Isoresistivity maps of the area up to 100m b.s.l,

Figure 1 shows a cross section down to 150m depth below sea level (b.s.l.) with a horizontal profile spreading over the 7 km in Padiyathalawa hot spring area. Figure 2 shows isoresistivity maps for the depths 30m above sea level, 0 m (sea level), 30m b.s.l, 50m b.s.l., 75m b.s.l. and 100m b.s.l. in the same area.

Collaborators

1. Prof. T. Iimoto, Tokyo University, Japan
2. Dr. S.P.K Malaviarachchi, University of Peradeniya
3. Mr. Prasad Mahakumara - Atomic Energy Authority
4. Mr. Nalin de Silva - Geological Survey and Mines Bureau

Human Resource Development

Students registered for M.Phil. and Ph.D.

1. N.B. Suriyaarachchi, IFS, registered for MPhil., PGIS, University of Peradeniya
   Title: *Mapping Geothermal resources in Sri Lanka: combine use of magnetotellurics and other techniques*

2. T.B. Nimalsiri, IFS, registered for MPhil., PGIS, University of Peradeniya
   Title: *Characterization of thermal springs in Sri Lanka; a combined geological, geophysical and geochemical approach*

3. D.R. Charles, IFS, registered for MPhil., PGIS, University of Peradeniya
   Title: *Estimate subsurface extension of Eppawala appetite deposit and its parent rock using geophysical techniques*

4. B. Jayatilake,IFS, registered for MPhil., PGIS, University of Peradeniya
   Title: *Anodic oxidation of phenol in contaminated water on dimensionally stable anode*

5. P.D. Mahakumara, Atomic Energy Authority, registered for PhD., PGIS, University of Peradeniya
   Title: *Preliminary study on Radon/Thoron Levels in Sri Lanka*

6. P.L. Dharmapriya, registered for MPhil., PGIS, University of Peradeniya Research area: Petrology,

Undergraduate trainees

1. S.A.R.H.S. Arachchi - University of Peradeniya
2. A.V.U.P. Amarathunge- University of Peradeniya
3. M.M.D. Marasinghe - Rajarata University
4. C.S. Suriyakula- Rajarata University
5. H.P.V.H. Erandi - Uwa Wellassa University

Volunteers

1. B.D.K.K. Thilakarathne
2. H.A. Dullewa
3. K.A.D.M.J.K. Wijeratna

7.1.4 NANOTECHNOLOGY AND PHYSICS OF MATERIALS

Project Leader: Dr. H.W.M A C. Wijayasinghe *(Research Fellow)*

Description of the Project

Nanotechnology and Physics of Materials are two of the most progressive branches in the Materials Science and Technology field, which can play a pivotal role in improving economic performance and the quality of life. Nanotechnology, which is considered as a key technology for the future, has already been able to create many new materials and devices for a vast range of applications.

Sri Lanka is well known for processing a variety of economically useful minerals, which are mainly being exported as cheap raw materials but contributing in a major way to the global materials based industry. Proper value addition to our economically useful local materials has almost been lacking, due to dearth of local research on our materials base. However, the recently endorsed National Nanotechnology Initiative facilitates scientists to investigate into applications in nanotechnology with a view to add value to practically every aspects of our exports and thereby achieving technological progress and competitiveness.

By considering these factors, our project mainly investigates the value addition strategies to Sri Lankan minerals and related materials, to upgrade them for nano-technological and high-tech industrial applications. Apart from that, this project involves with developing low-cost and performance enhanced advanced materials for energy conversion using low-cost synthesis techniques and value addition to Sri Lankan minerals. The Nanotechnology and Physics of Materials Project at the IFS commenced its work in January 2013 and conducts under the following two areas;

Upgrading Sri Lankan graphite for nano-technological and high-tech industrial applications

Global consumption of natural graphite is presently growing over 5% per year, mainly due to novel green and nano-technological initiatives. Sri Lanka is the only commercial producer of vein (lump) graphite grade, which is the rarest and most valuable form of graphite. Many specialized markets command premium prices for natural graphite but require upgrading through purification and further modification. By considering this, exploration of upgrading processes for Sri Lankan graphite is carried out via introducing advanced but low-cost purification and surface modification techniques. The investigations are further extended for developing the upgraded graphite for intended nano technological and high-tech industrial applications such as in graphene production, carbon nano tubes, rechargeable batteries ...etc.

Development of low-cost and performance enhanced materials for rechargeable batteries

With the recent introduction of portable electrical/electronic items and specially the electric vehicles, the demand for the portable energy cannot be met with the present conventional batteries. This is being addressed with the introduction of novel rechargeable batteries. However, their materials related problems and the expensiveness of the electrode materials are preventing the reach of this versatile portable power sources to the common mass. By considering this problem, development of low-cost and property enhanced advanced materials for rechargeable and primary batteries (Li-ion, Mg-ion, Na-ion and Ag-ion batteries), using novel nano-material synthesis techniques is carried out under this project.Furtherinvestigations will be performed for component fabrication and devising these power sources using the material components developed in Sri Lanka.

Collaborators

1. Dr. N.W.B. Balasooriya, Senior Lecturer / Department of Physical Sciences, Faculty of Applied Sciences, South Eastern University

Senior Staff Technical officer: **Mr. W. G. Jayasekara**

7.1.4.1 Development of $Li(Ni_{1/3}Mn_{1/3}Co_{1/3-x}M_x)O_2$ electrodes for the Li-ion rechargeable battery

N. B. Weerakoon[1], D. B. Senarathna[1], B. P. Nilanchani[2], N. G. Amaraweera[2,3], P.B. Samarasinghe[4], W. G. Jayasekara[3], A. Wijayasinghe[3], M.A.K.L. Dissanayake[3]

[1]Department of Natural Science, Open University of Sri Lanka, Nugegoda, [2]Department of Science and Technology, Uva-Wellassa University, Badulla, [3]Nanotechnology/Physics of Materials Project, Institute of Fundamental Studies, Kandy ,[4]Center for Materials Science and Nano Technology, University of Oslo, Norway

Introduction

$Li[Ni_{1/3}Mn_{1/3}Co_{1/3}]O_2$ is presently being commercialized as the cathode material for rechargeable Li-ion batteries (LIB). However, contained with very expensive cobalt, this cathode material is limited to consumer electronics and still too costly for vehicular applications.

Objectives

The objective of this study was to reduce the material cost of LIB cathode by fully or partially substituting expensive Co with other cheaper elements. It was carried out by developing less expensive but performance enhanced cathode materials for the LIB based on the system, $Li(Ni_{1/3}Mn_{1/3}Co_{1/3-x}M_x)O_2$,M = Fe, Al, Cu, Mg, Ba and x = 0 to 0.33. The material synthesis was done by Pechini and Glycine Nitrate combustion techniques, followed by phase and electrical characterizations. The fabricated electrodes were cell tested with $Li/LiPF_6/ Li(Ni_{1/3}Mn_{1/3}Co_{1/3-x}M_x)O_2$ coin cells cycling between 3.0 - 4.5 V.

Results

X-ray diffractometry phase analysis revealed the formation of solid solutions of appropriate layered R3m structure in the prepared compositions up to x = 0.11, except with Mg. Further, most of these prepared materials showed considerably higher electrical conductivity than the base material $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ (where it was 0.9×10^{-5} S/cm). In the cell studies, the Fe substituted composition with x = 0.11, showed a specific capacity of 122 $mAhg^{-1}$, which is better than the expensive state of the art cathode material of LIB. Hence this study revealed the possibility of preparing cheaper cathode materials suitable for LIBs.

7.1.4.2 Upgrading Sri Lankan graphite for nonotechnological and high-tech industrial applications

N.C. Manthrirathna[1], C.N. Wewegedara[1], N.G. Amaraweera[1,2], W.G. Jayasekara[2], N. Balasooriya[3],A. Wijayasinghe[2], M.A.K.L. Dissanayake[2]

[1]Department of Science and Technology, Uva-Wellassa University, Badulla
,[2]Nanotechnology/Physics of Materials Project, Institute of Fundamental Studies, Kandy,
[3]Department of Physical Sciences, South Eastern University, Sammanthurei

Introduction

Natural graphite has been identified as a cost effective source for a number of advanced nano-technological and high-tech industrial applications, such as for lithium-ion batteries, fuel cells, solar cells, semi conductors, nuclear reactors, graphene and carbon nano-tube production..etc. Although Sri Lankan natural vein graphite is renowned for its purity and crystallinity, it requires upgrading through purification and further modification for these applications.

Objectives

Our present research work on Sri Lankan graphite is based on purification and surface modification of different morphological varieties of local graphite suitable for intended nano-technological and high-tech industrial applications. The purity enhancement is carried out via introducing low-cost and efficient physical and chemical purification techniques, such as acid leaching and alkali roasting. The development of purified graphite for the intended applications is performed via surface modification by thermal oxidation, chemical oxidation, alkali coating, forming graphite-metal composites, … etc.

Results

Sri Lankan vein graphite can be effectively purified by treating with mineral acids with low concentrations at low temperature (eg: 5-20 vol.% HCl solutions at 60 ^{0}C). Accordingly, graphite with 95.0 to 99.8 % of initial carbon content could be upgraded into 97.5 to 99.99 % of carbon, respectively. Chemical oxidation is reported be more effective than the thermal oxidation, in modifying the purified graphite surface. It further indicated the possibility of preparing composite silver-graphite and alkali coated graphite without diminishing the electrical property of purified graphite.

7.1.4.3 Investigation on transition metal oxide cathode materials for novel rechargeable batteries

R.Y. Wickramarathne[1], H. R. Padmasiri[1], W. G. Jayasekara[2], A. Wijayasinghe[2]

[1]Department of Science and Technology, Uva-Wellassa University, Badulla,
[2]Nanotechnology/Physics of Materials Project, Institute of Fundamental Studies, Kandy

Introduction

Mg-ion and Na-ion secondary batteries, which utilize mostly abundant magnesium and sodium, are expected to be cheaper alternatives for rechargeable batteries. Improvement of these novel rechargeable batteries is mainly based on development of electrode materials leading to higher energy densities.

Objectives

Synthesis and characterization of low-cost and property enhanced cathode materials based on $M_xMn_{1-x}O$, M = Mg, Na and x = 0 - 1, systems for Mg-ion and Na-ion rechargeable batteries.

Results

These materials were synthesized by Glycine Nitrate Combustion (GNC) technique and characterized for the electrical conductivity. Most of the prepared materials showed higher room temperature electrical conductivity than the MnObase material (3.3×10^{-6} S/cm). Among them, the $Na_{0.25}Mn_{0.75}O$ composition reported the highest conductivity of 3.6×10^{-5} S/cm. Hence this study revealed the potentiality of $M_xMn_{1-x}O$, M = Mg, Na for the intended applications.

References

1. Reddy, B. Handbook of batteries, 3rd ed. McGraw-Hill, New York, 2001
2. Slater, M. *Advanced Functional Materials*, 2013, 23(8), 947

7.1.4.4 Development of a low-cost and multifunctional household water purifier

G.D.K. Heshan[1], W. G. Jayasekara[2], G. Amaraweera[1,2], A. Wijayasinghe[2]

[1]Department of Science and Technology, Uva-Wellassa University, Badulla
[2]Nanotechnology/Physics of Materials Project, Institute of Fundamental Studies, Kandy

Introduction

Sri Lanka is already facing challenges in terms of providing clean and safe drinking water. Point-of-use water treatment techniques such as household water filters offer an affordable and effective means of treating water suitable for drinking. Sri Lanka is well known for possessing a variety of minerals and related materials suitable for water purification. However, for very effective water purification, the related properties of these materials should be enhanced through morphological changes or material treatments.

Objectives

Design and construction of an advanced but low-cost multifunctional water purifier for Sri Lankan household use, using developed local minerals and related materials. This project addresses two areas of research and developments, first upgrading of Sri Lankan minerals and related materials for water

purification using modern materials processing techniques, and secondly improving the quality of drinking water for Sri Lankan household use.

Results

Initial investigations show the ability of processing our cheaper local minerals and related materials (kaolinite, bentonite, garnet, quarts, clay bricks, wood charcoal, activated carbon … etc.) for effective water purification. A working model of the purifier has been constructed and successfully demonstrated. Investigations on the effectiveness of the purifier with different water sources and further modification of the purifier for different usages are being carried out.

Human Resource Development

Registered for Ph. D.

1. T.H.N.G. Amaraweera (HETC scholarship holder, Uva-Wellassa University), PGIS, University of Peradeniya.
   Tentative thesis title *Development of Sri Lankan Minerals and Low Cost Synthesized Materials for Lithium-ion Rechargeable batteries*

Undergraduate trainees

1. A. B. D. B. Senarathna, Natural Science, Open University of Sri Lanka
2. N. B. Weerakoon, Natural Science, Open University of Sri Lanka
3. B. P. Nilanchani, Materials Science & Technology, Uva-Wellassa University
4. R.Y. Wickramarathne, Materials Science & Technology, Uva-Wellassa University
5. D. H. R. Padmasiri, Materials Science & Technology, Uva-Wellassa University
6. N. C. Manthrirathna, Materials Science & Technology, Uva-Wellassa University
7. C. N. Wewegedara, Mineral Resources & Technology, Uva-Wellassa University
8. Y. V. Madushanka, Mineral Resources & Technology, Uva-Wellassa University
9. G.D.K. Heshan, Materials Science & Technology, Uva-Wellassa University
10. A. Dissanayake, Applied Science, University of Peradeniya

7.1.5 PHOTOCHEMISTRY

Project Leader: Prof. J. Bandara *(Research Professor)*

Harnessing Solar Energy by Artificial Photosynthesis as an Alternative Energy

Description of the Project

Our dependence on oil and electricity consumption makes energy a key factor in our society. Fossil fuel which is our main energy resource is depleting at a rapid rate making the future energy crisis prominent and will result in sky-rocketingenergy prices. We therefore need to urgently find ways to produce energy using renewable energy sources. Out of the possible alternative energy sources, solar energy is found to be one of the prime targets to achieve the global energy requirements. Solar-drivenproduction of environmentally clean electricity, hydrogen and other fuels is considered as the only sustainable solution for global energy needs.

Solar energy can be converted into electricity and chemical energy by mimicking the natural photosynthesis as shown in schematically in Figure 1. The Photochemistry group at the IFS is actively involved in investigating theconversion of solar energy into useful energy resources by artificial photosynthesis.

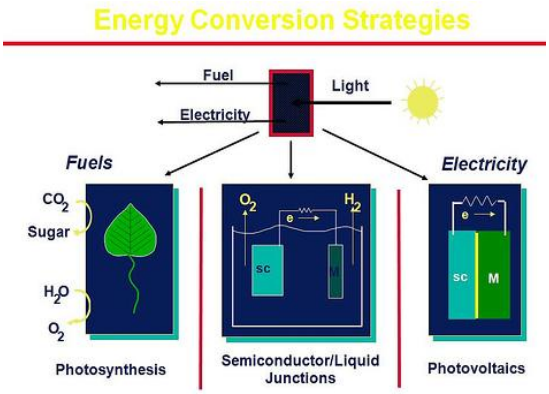


Figure 1

The Photochemistry group at the IFS conducts research on the conversion of solar energy into electricity, fuel and removal of water pollutants. The research work of the Photochemistry Group is divided into three major projects;

(1) Extending and adapting current photovoltaic technology mainly dye-sensitized, Q-dot sensitized solar cells as well as meso-superstructured solar cells and polymer solar cells to generate electricity directly from solar radiation.

(2) Constructing artificial chemical devices mimicking photosynthesis to collect, direct, and apply solar radiation, for example to split water, convert atmospheric carbon dioxide and thus produce various forms of environmentally clean fuels.

(3) Chemical, Electrochemical and Photochemical methods for the purification of water and air.

In addition to these major projects, the Photochemistry Group commenced research work in 2011 on Chronic Kidney Disease of unknown etiology.

Group members from left to right

D. Aluthpatabedi	Water purification techniques (senior staff technical officer)
A.Manjceevan	DSSC based on Q-dot (Research Assistant)
R. Rajapaske	DSSC (Research Assistant)
S. Kulatunge	DSSC based on 1-D nanostructures (Research Assistant)
J Bandara	Project leader
J. Akilavasan	DSSC based on 1-D nanostructures (Research Assistant)
U. Gunatilaka	Water purification techniques (Research Assistant)
L. Silva	Water splitting reaction (M.Sc. student)
A. Gannoruwa	Water splittingreaction (M.Phil. student)
M.S. Wasana (absent)	Water quality (Ph.D. student)

7.1.5.1 Conversion of Solar Energy into Electrical Energy

J. Akilawasan, K.T. Wijerathne, A. Manjceevan, S. Kulatunge, R. Rajapakshe, J. Bandara

Photochemistry Project, Institute of Fundamental Studies, Kandy

Introduction: Dye sensitized solar cells (DSSCs) are widely recognized as a promising alternative for conventional silicon based solar cells with an economically viable cost. An efficiency of 11% has been reported for DSSC based on mesoporous nanoparticles of TiO_2 and N719 dye with a liquid electrolyte. One of the major drawbacks of the nano-crystalline based device is the recombination of free electron with oxidized dye molecules and also with I_3^-. The recombination usually occurs at particle boundaries within TiO_2 layer which is mainly due to the randomly oriented nature of the nano-crystalline particle network and the poor contact between TiO_2 nanoparticles.To address this issue, the use of one dimensional (1-D) nano-structured oxide semiconductors has drawn enormous attention. In this respect, there has been an intensive research on 1-D nano-materials such as nanotubes and nanorods during the last decade. The nanotube arrays are generally prepared by anodic oxidation of titanium or titanium film in fluoride based electrolytes. Since the anodic oxidation process is not a cost-effective method, finding cost effective methods such as the hydrothermal method or sol-gel process is vital for commercialization of the product. As the hydrothermal process is a simpler wet chemical process, it is more favourable for large-scale reactions and production of low cost material for the formation of TiO_2 nanotubes-nanorods compared with other methods, such

as anodization[23] or surfactant-assisted templating[24] methods. Hence, Photochemistry Group investigates the hydrothermal method for the synthesis of different nanostructures such as ZnO, SnO_2 and TiO_2 nanotubes and nanorods.

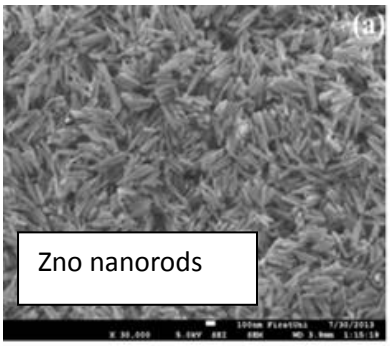
Objectives

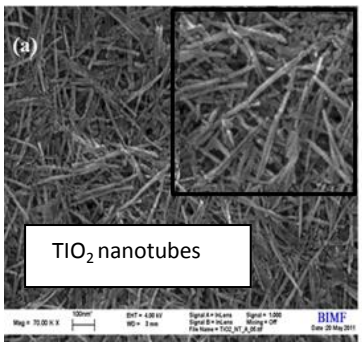
Fabrication of dye-sensitized solar cells, Bulk Hetero Junction Solar cells and hybrid solar cells for the conversion of solar energy into electrical energy.

Results

Efficient solar cells were fabricated with ZnO and TiO_2 nanotubes. The reported efficiency 7.6% is the highest ever solar cell performance for the hydrothermally synthesized TiO_2 nanotube electrode. $TiCl_4$ treatment of hydrothermally synthesized TiO_2 nanotube results in increase in charge transport as well as charge recombination. By the introduction of a light scattering layer to the TiO_2 nanotube photoandoe, an efficiency of ~ 9% was achieved. Solar cells fabricated with ZnO and SnO_2 nanotube/nanorods also showed a remarkable performance but efficiency of these photoelectrodes were inferior to that of TiO_2 nanotube.

On these nanotube films and nanoparticles, Q-dots of CdS and PbS were deposited and current density of 25-30 mA/cm^2 was achieved. However, open circuit voltage of these q-dot solar cells were found to lower than expected and research is underway to understand and enhance the open circuit voltage of q-dot sensitized solar cells.





7.1.5.2 Conversion of Solar Energy into Chemical Energy

A. Gannoruwa[1], D. Aluthpatabedi[2], J. Bandara[2]

[1]Uwa-Wellasa Univeristy,Badulla, [2]Photochemistry Project, Institute of Fundamental Studies, Kandy

Introduction

Photocatalytic water splitting into hydrogen is an effective method of converting solar energy into chemical energy and hydrogen is a promising alternative to fossil fuels since it contains 3.4 times more energy than gasoline on a weight basis. Most of the photocatalysts are active either in UV or visible region of the solar spectrum. However no attempts have been made to develop solely IR active photocatalysts even though solar spectrum comprises of 50% IR radiation. Here we investigate the synthesis of an IR active photocatalyst for production of H_2 from photolysis of water.

Objectives

Conversion of solar energy into chemical energy using low-energy IR radiations

Results

Table 1 summarises the hydrogen yields with different conditions. We found, for the first time, that Ag_2O/TiO_2 composite prepared by a chemical deposition method was able to split water to produce H_2 even without a sacrificial agent by using low-energy IR radiation. The photocatalyst was found to absorb low-energy IR radiation byOptical Near-Field Photon assisted multi-photon photoexcitation photoexcitation and generate active electron-hole pairs that participate in the water splitting reaction generating H_2. Our results clearly demonstrate the possibility of synthesising new types of photocatalysts to harness the IR region of the solar spectrum for the production of fuels such as H_2. The present IR photon harvesting system can be applied not only to the photolysis of water but also for the photodegradation of pollutants and in solar cells. Hence, this will be a promising artificial system for efficient harvesting of solar energy.

Table 1: H_2 yield by photolysis of 10% methanol and deionised water under IR irradiation per unit catalyst mass with total intensity of 3.2 mW cm^{-2}.

Catalyst	H_2yield (ml h^{-1} g^{-1})			
	10% methanol		Deionised water	
	Under Ar	Under air	Under Ar	Under air
Ag_2O/TiO_2	25.64 ± 0.56	5.83 ± 0.39	2.41 ± 0.06	0.176 ± 0.002
TiO_2	2.41 ± 0.82	0.19 ± 0.02	0.55 ± 0.04	0.04 ± 0.003
Ag_2O	0.56 ± 0.18	0.17 ± 0.07	0.11 ± 0.009	0.017 ± 0.006

7.1.5.3 Photochemical Purification of Water and Air

U. Gunatilake, J. Bandara

Photochemistry Project, Institute of Fundamental Studies, Kandy

Introduction

Automobile service station wastewater has been a heavy environment pollutant and a major topic of environment science fields. The service station wastewater pollutes surface water sources as well as ground water sources. Tests conducted on fluid samples from service station floors'drains indicate that improper disposal of waste generated during vehicle servicing poses the threat of ground water contamination. Automobile service station wastewater may contain several hundred milligrams per liter of benzene, oil, grease and other volatile organic compounds. Waste solvents contain a high percentage of chlorinated hydrocarbons. Some of these chemicals are known or suspected carcinogens.

In order to comply wastewater which is discharged into the environment, with Maximum Contaminant Levels that wastewater must undergo proper treatment. Designing of a wastewater treatment plant is a very important area in environment engineering. The treatment plant should be able to discharge wastewater under Maximum Contaminant Levels which are established by local authorities. It must be capable of catering its service for average capacities and also for possible maximum volumes.

Objectives

Design of Biological and Advanced Oxidation Technology (AOT) hybrid reactor system for oil wastewater treatment

Results

- Superhydrophobic layers were prepared by using a nanocomposite. Polystyrene was taken as a polymer matrix and the modified $TiO_{2\ (S)}$ nanoparticles were taken as the dispersed nano phase. Hydrophilic $TiO_{2\ (S)}$ nanoparticles were transformed to hydrophobic by treating them with fatty acids. Spraying method was used to attach the nanocomposite to the cotton cloth.
- Suerhydrophobic properties of the polystyrene polymer coating were increased by optimizing conditions (temperature, solvents, concentration)
- The problem that encountered up to now is the stability of the layer. When using the layer continuously, the polymer fibers tend to be destroyed.

(A) (B) (C)

Figure 02; (A) Superhydrophobic layer, (B), (C) Water droplets on the layer

7.1.5.4 Chronic Kidney Disease of Unknown Etiology

M.S. Wasana[1], D. Aluthpatabedi[1], R. Weerasooriya[2], J. Bandara[1]

[1]Photochemistry Project, Institute of Fundamental Studies, Kandy ,[2]University of Peradeniya, Peradeniya

Introduction

Chronic kidney disease (CKD) is a worldwide public health problem and it is receiving increased global attention because of the rapid spread of the disease. Aging, diabetes, hypertension, and nephrotoxic drugs usage are known to be primary risk factors for CKD. However, CKD of unknown etiology (CKDu) is also prevalent and rapidly progressing in some regions of the world notably in Africa, Central America and Asia. The term "unknown etiology" refers, because the disease is not associated with any known risk factors. If not properly treated, CKD can lead to end stage renal disease and often death. Recent studies revealed that there is an increasing trend in mortality due to etiology unknown chronic kidney disease. Although precise epidemiological data are lacking to date in most cases, it has been identified that occupational and environmental causes are the main reason. The natural substancesaristolochic (Debelle et al, 2008) acid and ochratoxin A havebeen related to CKDu outbreaks and long-termexposures to trace elements have been revealedas possible causes of renal damage. In South Asian countries like Sri Lanka, it is noted for an alarming high incidence of CKDu during last three decades. The disease is characterized by a slow, progressive, asymptomatic development, frequently starting at a younger age group. A steady increase of this disease has been observed during the last twenty years. At present, CKDu is a severe health problem in Sri Lanka.

Objectives

To detect the fluoride and some selected metal ion concentration ($Al^{+3,}$ Cd^{+2}, $Pb^{+2,}$ $Ca^{+2,}$ Mg^{+2}) of drinking water in Anuradhapura district with reference to the Chronic Renal Failure. To detect the effect of AlF_x compounds on Chronic Renal Failure (Rajarata Kidney Disease).To develop an

effective and economical method in order to reduce the Fluoride concentrations in drinking water up to the WHO standards.

Results

In spring waters the concentrations of F, Cd, As and hardness showed lowest values. Aluminum levels are comparable (except in treated water) in other areas and the spring water. No CKDu incidence was reported where people consumed spring water for a considerable period of time (more than ten years). It is suspected that the high quality of the spring water and the lack of possible causative CKDu agents may keep the people healthy. In all areas examined, the average Cd and As levels are below the WHO recommendations (Cd 3µg/L and As 10 ppb); hence, these elements alone cannot be causative factors for the disease etiology. A positive correlation between the fluoride concentration in drinking water and the prevalence of the CKDu were noted. However, the fluoride in water cannot be considered causative since low CKDu prevalent areas were also located in high fluoride zones. Therefore it is conferred that fluoride in water is not acting alone and it is triggered by other factors. The triggering factor(s) could be either hardness or Cd or it could be synergic effects of F, Cd and hardness. It is inferred that both mechanisms are actively responsible for triggering CKDu. This observation needs further validations by animal trial experiments. It is recommended to utilize either treated or spring water as a preventive measure of CKDu in the regions examined.

Publications

Total SCI publications since inception: 42 (1999-2013)
Total SCI publications in year 2113: 02
Human Resource Development

Registered for Ph.D/M.Phil. at PGIS, University of Peradeniya

1 J. Akilavasan, extended registration for Ph.D.
Title :*Quantum Dot Sensitized Solar Cells Based on Titania Nanotubes*

2 W. Wasana, extended registration for Ph.D.
Title: *Quality of drinking water in Rajarata area and the CKD disease*

3 K. Wijerathne, registered for M.Phil
Title: *1-Dimentional SnO_2 and ZnO Nanocomposites for enhancing the power conversion efficiency of DSSC*

4 A.Manjceevan, registered for M.Phil.
Title: *Fabrication of tandem solar cells to harvest solar energy for wide spectrum*

5 K.U.B.Gunathilake, registered for M.Phil.
Title: *Design of a Biological and Advanced Oxidation Technology (AOT) Hybrid Reactor System for Oil Wastewater Treatment at Automobile Service Stations*.

6 K.M.S.D.B. Kulathunga, registered for M.Phil.
Title: *1-D material for dye sensitized solar cells*

7 Asangi Gannoruwa, registered for M.Phil.
Title: *Photowater splitting using tandem solar cells*

Two graduate students from PGIS work on their research projects.

K. Wijerathne, Completed his M.Phil research work and commenced his PhD work in Sweden in 2013.

7.1.6 THERMOELECTRICITY

Project Leader: N.D. Subasinghe *(Senior Research Fellow)*

Description of the Project

Thermoelectricity project investigates the use of thermovoltaic (TV) devices to generate electricity from waste heat and solar energy. A thermoelectric device is an energy conversion system that converts thermal energy directly into electrical energy. A device of this type is commonly referred to as a thermoelectric generator (TEG).

The maximum theoretical efficiency available in an engine operating between two temperatures is the Carnot efficiency. Photovoltaic (PV) devices have net conversion efficiencies in the teens and thermionic (or thermoelectric) chips reach only a little higher than 20 percent of Carnot when converting heat to electricity.

Currently, the converting heat energy to electricity in large scale is done by using steam engines. They can only operate at a higher temperature range (usually above 120 °C) and they cannot be scaled down for small scale applications. Moving parts such as turbines and pistons lead to the parasitic energy losses and noise, greatly lowering the efficiency. In contrast, TEGs have no moving parts, totally silent in operation and they can be easily scalable to any scale, even down to nano-level. Currently the focus of this project is on optimizing the design and layout to increase the efficiency.

This project was started with following objectives in mind:

- Introducing and initiating one of the timely fields of research in Sri Lanka.
- Developing interest and awareness on thermoelectricity and its applications in Sri Lanka.
- Understanding the effect of different parameters and geometry of elements on the TE power output.
- Developing TE modules that are cheap, affordable and practical.
- Developing more efficient TE modules using non-conventional assembly methods.
- Production of TE generators that can run on any locally available energy source (e.g. solar energy, waste heat from cooking or from factories, heat from burning straw, rice husk or dried weeds).
- Investigation of possibility of producing TEG units as a local/domestic industry (similar to the production of solar water heaters in Sri Lanka)

One of the major advantages of the TV modules over PV modules is that TV modules can generate electricity using any available heat source, not only the solar energy. The source of heat could be solar energy, waste heat from an industry or from a domestic cooker.

It is expected that the outcome of this project will eventually contribute to the economy of Sri Lanka, by providing a cheap alternative energy source, especially for the people who are still without grid connections.

7.1.6.1 Development of a low-cost thermoelectric generator for small applications

N.D. Subasinghe[1], N.B. Suriyaarachchi[1], T.B. Nimalsiri[1], D. Marasinghe[2]

[1] Institute of Fundamental Studies, Kandy.[2]Rajarata University, Mihintale

Introduction

Thermoelectric generators (TEGs) essentially consists of 'hot' and 'cold' junctions made of two different materials. Depending on the difference of "*Seebeck coefficients*" of the material, potential differences are generated. While there are semi-conductor based expensive TEGs in the market, we are experimenting with cheaply and locally available material to produce small-scale 'power-on-demand' devices.

Objectives

1. To study the effect of design and physical parameters on the output of a TEG
2. To study the actual output of the TEG modules produced with locally available, cheap or recycled material and compare it with their theoretical output.

Results

Experiments were carried out with different combinations of locally available material to study the power output. Results are summarised in the following graph.

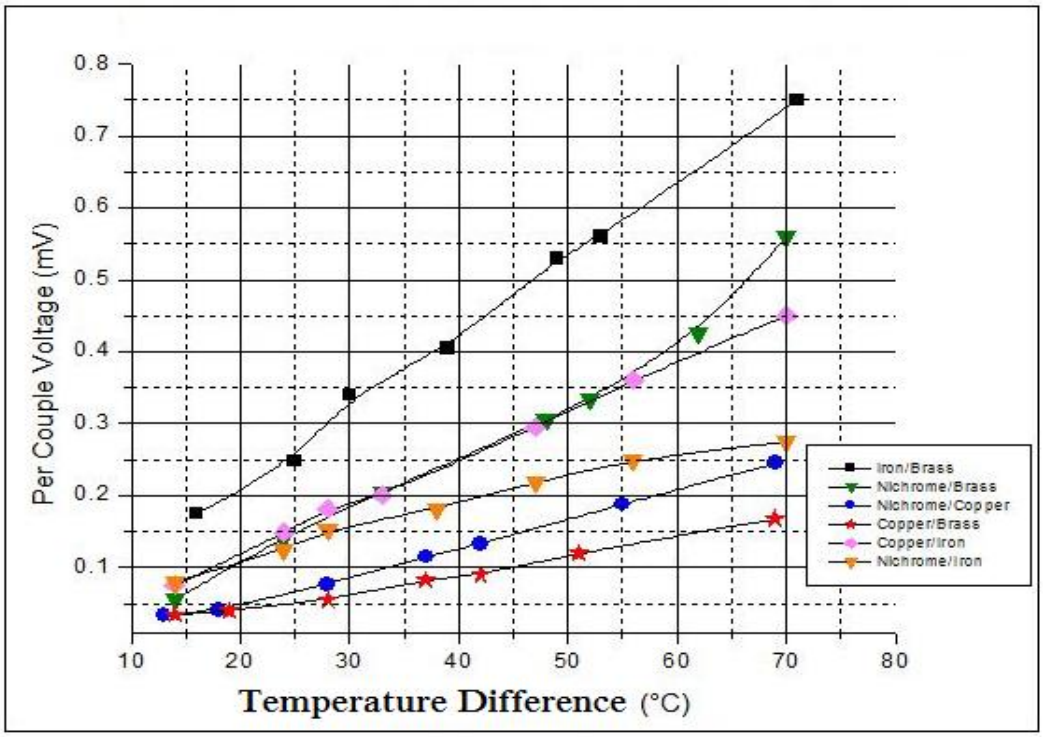


Fig. 1 A graph showing the variation of output voltage (per thermocouple) with temperature difference, for different material combinations.

As shown in Figure 1, the highest output was observed in iron/brass combination.

7.2 CHEMICAL AND LIFE SCIENCES

7.2.1 CELL BIOLOGY

Project Leader: Dr. D.N. Magana-Arachchi *(Senior Research Fellow)*

Description of the project

The Plant Cell Biology project was initiated in 2004 December with research on cyanobacteria. In 2009 the project was renamed as Cell Biology. Currently, research is being carried out in two main areas – cyanobacteria and tuberculosis, with sub projects in each category in order to explore resources, improve human welfare and contribute to national development.

Isolation & identification of microorganisms and their effects on humans

Cyanobacteria, previously referred to as blue-green algae, are a diverse group of microorganisms that inhabit a wide range of ecological niches and are well known for their toxic secondary metabolite production. Knowledge of the evolution and dispersal of these microorganisms is still limited, and further research to understand such topics is vital. Recently, the biotechnological potential of cyanobacteria and archaea is attracting increasing attention. The present study provides information on the enormous diversity and wealth of cyanobacterial and archaeal diversity in Sri Lanka. The cyanobacterial toxins are potential human health hazards and these are known to occur widely in drinking water sources. Therefore studies were carried out to identify potential microcystin-producing cyanobacteria from environmental samples and cultured isolates. 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 is necessary to minimize potential health risks. The first part of the project was completed in November 2013. Based on this research, a Ph.D thesis was submitted to the University of Colombo in December.

Cyanotoxins&Chronic Kidney Disease of unknown aetiology (CKDu)

Toxic cyanobacteria are increasingly being perceived as a potential health hazard, particularly in waters used for drinking and recreation. Exposure to such cyanobacterial toxins in freshwater systems, including both direct and indirect routes, is emerging as a potentially significant threat to human health. Among the cyanotoxins, microcystins and cylindrospermopsin are the predominant toxins in freshwater lakes worldwide. Concern about cyanobacterial blooms in fresh waters in Sri Lanka has also grown in recent years due to an epidemic of CKDu prevailing in the North Central Province and other surrounding areas. However, the incidence, aetiology, and demography are largely unknown and only a few studies have been published. The reason might be due to the combined effect of chemical and biological compounds, probably cyanotoxins, present in water sources of such areas. Therefore, identification of such cyanobacteria in water sources would provide long term objective of providing new, rapid, molecular monitoring capability for tracking cyanotoxin producing cyanobacteria. Therefore, we targeted the cyanotoxins as a biological contaminant to establish the value of using molecular, biochemical and bioassay techniques to determine the presence of cyanotoxins. The project is in the final stages of completion.

Gene expression analysis: Identifying the missing link in chronic kidney disease of unknown aetiology (CKDu) in Sri Lanka

Studies have not been conducted as yet, to determine the gene expression analysis of these CKDu patients. Therefore, by doing this pilot study, we can determine the gene expression patterns for selected genes (drugs, xenobiotics, environmental factors, oxidative stress, heavy metals, diabetes, etc.) using Real-Time Polymerase Chain Reaction (RT-PCR) arrays with RNA expressions on human

control and diseased kidney samples. The identification of gene expression patterns (potential biomarker patterns) that are associated with progression of CKDu, will enable us to determine the possible risk factors.

Multidrug-resistant Tuberculosis (MDR-TB)

MDR-TB is a problem of great importance to public health, with higher mortality rates than drug-sensitive TB. From our study we were able to develop a molecular technique to detect mutations in *M. tuberculosis* strains and thereby resistance to two main drugs – isoniazid and rifampin, simultaneously. The project was completed in 2012 October and in 2013 October; a patent application was submitted to NIPO in Sri Lanka.

A rapid method to detect non-tuberculosis mycobacteria (NTM)

Atypical mycobacterium is one of the common infection-causing organisms, which affect immuno suppressive patients and patients with pre-existing lung diseases. From our studies, a molecular assay was optimized to differentially detect slow growing and rapidly growing non tuberculous *Mycobacteria* (NTM) directly from sputum specimens. The project was completed in March and the final report was submitted to the National TB Control Programme.

An optimized MIRU-VNTR typing system and Spoligotyping for population-based molecular epidemiological studies of tuberculosis

Mycobacterial strain typing by means of molecular methods has become an important instrument for tuberculosis surveillance, control and prevention. The present study focuses on characterization of *M. tuberculosis* isolates, obtained from patients attending the Central Chest Clinic in Kandy and from Bogambara prison by the MIRU-VNTR typing system and Spoligotyping to study the person-to-person transmission of pulmonary TB among different populations.

Culturing of *Spirulina* on a large scale

The major objective of the current project is to popularize culturing *Spirulina* on a large scale in the country by collaborating with the Mahatma Gandhi Centre. *Spirulina* is to be used as a low input self-supporting commercial venture. Presently stock cultures of *Spirulina* are maintained at laboratory conditions and by using the newly formulated medium with cost-effective alternative chemicals, semi-mass culturing of *Spirulina* is carried out in open tanks under greenhouse conditions.

Collaborators

1. Dr. N.V. Chandrasekaran, University of Colombo
2. Prof. V. Thevanesam, University of Peradeniya
3. Dr. S.D.S.S. Sooriyapathirana, University of Peradeniya
4. Dr. D. Medagedara, General Hospital, Kandy
5. Dr. L. Gunarathne, Girandurukotte Hospital
6. Dr. T. Abeysekara

7.2.1.1 Determination of Potential Microcystin-Producing Cyanobacteria in Sri Lanka

R.P. Wanigatunge and D.N. Magana-Arachchi

Cell Biology Project, Institute of Fundamental Studies, Kandy

Introduction

The microcystins are a group of cyclic hepta peptide hepatotoxins produced by a number of strains of certain cyanobacterial genera. The presence of hepatotoxic microcystin in surface waters used for drinking and recreation is receiving increased attention around the world as a public health concern.

Objective

The objective of this study was to identify and characterize potential microcystin producing cyanobacteria in different water sources using PCR analysis.

Results

A total of 61 cyanobacterial isolates previously identified using 16S rRNA gene sequences were used for the study. Genomic DNA was extracted and purified using Boom's method. PCR amplification was performed with previously described primers mcyA-Cd 1F/mcyA-Cd 1R for the condensation domain of the *mcy*A gene and HEPF/HEPR for the aminotransferase domain of the *mcy*E gene of the microcystin synthesis pathway. Among the cyanobacterial isolates, *Microcystis aeruginosa* from Lake Gregory, Lake Beira and Ulhitiya reservoir and *Limnothrix* sp. from Nalanda reservoir yielded the expected PCR fragments of ~300 bp and 472 bp with *mcy*A and *mcy*E genes respectively. *Synechocystis* sp. from Lake Gregory and *Leptolyngbya* sp. from **Mahapelessa hot springs** gave the expected PCR fragment with *mcy*A gene. Further, *Leptolyngbya* sp. from Yala gave the expected PCR fragment with *mcy*E gene. Other tested cyanobacterial isolates did not produce expected PCR fragments with both primers. The presence of *mcy*A and/ or *mcy*E gene in the microcystin synthesis pathway confirmed the genetic potential of the microcystin-producing ability in cyanobacteria identified from Lake Gregory, **Lake Beira,** Nalanda reservoir, Ulhitiya reservoir, Mahapellessa hot springs and Yala. Being a rapid method, the technique could be used for the early detection of potentially toxic cyanobacteria in public water reservoirs in Sri Lanka.

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7.2.1.2 Cyanotoxins and Chronic Kidney Disease of unknown aetiology (CKDu)

H. M. Liyanage and D.N. Magana-Arachchi

Cell Biology Project, Institute of Fundamental Studies, Kandy

Introduction

Among the cyanotoxins, microcystins and cylindrospermopsin are the predominant toxins in freshwater lakes worldwide that affect the human liver and kidney function.

Aims and Objectives

The objective of this study was the isolation and molecular characterization of *Cylindrospermopsis* strains as well as to determine whether cyanotoxins are a risk factor for CKDu.

Results

330 Chronic Kidney Disease (CKD)/CKDu/Healthy individuals' questionnaires were analyzed to find-out any disease-causing relationships. Significant differences were observed for each factor under each category. Comparing the control + CKD population with the CKDu population, twelve factors showed a statistically significant difference ($p<0.05$). Microcystin (MC) and cylindrospermopsin (CYN) producing cyanobacteria were identified from 135 CKD/CKDu/Healthy individuals' water samples and 38 reservoirs samples. PCR amplification was done for 50 urine samples collected from CKD/CKDu patients to identify cyanobacteria in their excretory system. One sample was positive for cyanobacteria and was sequenced, confirming the presence of *Chroococcidiopsis* sp. in patient's excretory system. PCR amplification was done for 10 reservoirs and 12 environmental water samples collected from CKDu patients' water sources to identify cyanobacteria. In addition, PCR amplification was done for six reservoirs samples to identify *Cylindrospermopsis raciborskii.* Selected positive samples were sequenced. Morphological observations were carried out in 52 water samples collected from Thuruvila, Mahakandarawa, Nachchaduwa and Nuwarawewa reservoirs to find out any *Cylindrospermopsis* spp. None were identified except *Phormidium, Merismopedia, Microcystis, Chroococcus, Oscillatoria*spp and unknown spiral shaped organisms. DNA was extracted from six cultured samples and amplified for the 16S rRNA gene to find out whether this unknown spiral shaped organism is a cyanobacterium. Four positive samples were sequenced. The unknown organism was identified as a Prochlorales cyanobacterium. DNA (n=49) sequences were deposited in the GenBank. Two phylogenetic trees were constructed using 45 16S rRNA gene sequences and four *cyt* gene sequences. 24 uncultured cyanobacterial isolates were able to place on their taxonomic positions upto order level with 16S rRNA sequences. With *cyt* gene phylogeny, four *C. raciborskii* strains were found to be more identical (96% -100% sequence similarity) to the existing *C. raciborskii* strains in the NCBI database irrespective of their toxicities. HPLC analysis was carried out for four CYN samples extracted from four reservoirs in Anuradhapura. Three reservoirs' samples showed corresponding CYN peak with the same retention time of 7.5 min ±1 except the Jaya Ganga reservoirs' sample, and as such, confirmed the presence of CYN in Nuwarawewa, Tissawewa and Kala wewa reservoirs.

7.2.1.3 Detection of Non Tuberculosis Mycobacteria in bronchoscopy samples using PCR-RFLP assay

D.K. Weerasekera[1], D.N. Magana-Arachchi[1], D. Madegedara[2]

[1]Cell Biology Project, Institute of Fundamental Studies, Kandy,
[2]Respiratory unit, Central Chest Clinic, Kandy

Introduction

The rising incidence of human infection by non-tuberculous mycobacteria (NTM) is a serious public-health concern[1].

Objective

To identify mycobacterial species in bronchoscopy specimens with a simple assay based on PCR and restriction enzyme digestion.

Results

Among the culture-positive patients, PCR was able to distinguish 12 rapid growers (~280-320 bp), 15 slow (~200-220 bp) and 10 patients having both rapid and slow while one having two rapid growing mycobacteria. DNA sequence analysis revealed the presence of *M. intracellulare*(n=3), *M. phocaicum* (n=7), *M. tuberculosis* complex (n=13), *Nocardia* (n=2), *M. smegmatis* (n=1) and *Mycobacterium sp*(n=12). The identified organisms got digested upon exposure to *Hae*III restriction enzyme whereas when exposed to *Cfo*I, only *M. phocaicum* yielded 80 bp and 230 bp DNA fragments, while others remained undigested. Consequently, six patients were confirmed of having *M. tuberculosis* complex, seven having both *M. tuberculosis* and NTM in their bronchoscopy specimens while 21 were suffering from NTM diseases.Further, out of the 100 bronchoscopy specimens evaluated by the assay, five of the specimens had NTM while seven patients had both tuberculosis and NTM in their bronchoscopy specimens. Three patients had only *M. tuberculosis* complex bacterium while 24 patients had other organisms. From a total of 12 patients who had NTM, eight were rapid growers while the other four were slow growers. No DNA fragments were observed in the remaining 61 specimens. Optimized PCR-RFLP assay was able to differentiate *M. tuberculosis* complex bacteria from non-tuberculosis mycobacteria and *Nocardia*. Molecular analysis confirmed the presence of NTM in bronchoscopy specimens and according to the study, a significant proportion of patients, i.e, ~13-14% of the study population were found to have NTM in their bronchial washings.

7.2.1.4 Preliminary analysis of human gene expression in chronic kidney disease patients of the dry zone of Sri Lanka

S. Sayanthooran[1], D.N. Magana-Arachchi[1], S.D.S.S. Sooriyapathirana[2], T. Abeysekera[3], L. Gunarathne[3]

[1]Cell Biology Project, Institute of Fundamental Studies, Kandy, [2] Department of Molecular Biology and Biotechnology, University of Peradeniya, [2]Girandurukotte District Hospital

Introduction

Out of the CKD highly prevalent in the dry zones of Sri Lanka, majority of the cases are of unknown aetiology. The cause is however believed to be related to the environment. External environmental stimuli can regulate the expression of genes[1], and therefore changes in gene expression could point towards the stimulating environmental factor(s).

Objectives

To study expression patterns of genes related to drug metabolism (CYP2D6), diabetes and cardiovascular disease (IGFBP1, IGFBP3), oxidative stress (G6PD) and kidney damage (FN1) in chronic kidney disease patients of the dry zone of Sri Lanka.

Results

Blood samples and socio-demographic data were collected from chronic kidney disease patients attending the renal clinic of the Girandurukotte District Hospital. Ten patients with CKDu, four chronic kidney disease patients diagnosed prior with diabetes and/or hypertension, and three healthy individuals were taken into account for the study. RNA was extracted from the blood and first-strand Cdna was synthesized. RT-PCR was carried out for the genes using predesigned hydrolysis probes. The average threshold cycle (C_T) of healthy individuals was used as a baseline to calculate fold changes using $2^{-\Delta CT}$. Out of the genes studied, IGFBP3 and CYP2D6 expressions showed a correlation ($p<0.05$ and $p<0.1$ respectively) with the aetiology of disease, where CKD patients had a lower expression of the gene compared to CKDu patients, who in turn had a lower expression compared to healthy individuals. IGFBP1 expression showed a positive correlation with the history of diabetes ($p<0.05$) and stage of disease ($p<0.1$), whereas IGFBP3 expression showed a negative correlation with the stage of the disease ($p<0.05$). Other genes observed did not show a statistically significant correlation with study parameters on preliminary analysis.

Human Resource Development\

Registered for Ph.D., M. Phil, and M.Sc.

1. R.P. Wanigatunge (IFS), Registered for a PhD at University of Colombo
   Title; *Identification and characterization of cyanobacteria using 16S rRNA genes and detection of toxin producing cyanobacterial species using molecular markers*

2. H. M. Liyanage (IFS), Registered for a PhD at University of Colombo
   Title; *Identification and molecular characterization of Cylindrospermopsis, Cylindrospermopsin andpotential toxin producers in dry zone, Sri Lanka*

3. D.K. Weerasekera (IFS), Registered for a M. Phil at Faculty of Medicine, University of Peradeniya
   Title; *An optimized MIRU-VNTR typing system and spoligotyping for population-based molecular epidemiology studies of tuberculosis in three distinct population groups*

4. S. Sayanthooran (NRC), Registered for a M. Phil at the PGIS, University of Peradeniya
   Title; *Human gene expression analysis as a molecular marker to determine the causative agent in patients with chronic kidney disease of unknown aetiology (CKDu) in Sri Lanka*

5. T. Keerthiratne (IFS), Applied for M. Phil registration at the PGIS, University of Peradeniya
   Title; *Molecular identification and drug susceptibility of non-tuberculous Mycobacteria (NTM)*

Titles of theses completed

D.M.D.P.K. Bandara (Volunteer RA),

Title: *Detection of WISE gene in Mycobacterium tuberculosis*, 2013, University of Peradeniya

Undergraduate trainees

1. Y. Thanzeel, University of Peradeniya, one month (Full time/Part time)
2. C. Samarawickrama, University of Peradeniya, one month (Full time/Part time)

Volunteers

1. N. Perera, Eight months (Full time)
2. C. Rajapakshe, Four months (Full time)
3. S. Gangoda, Three months (Full time)
4. V. Bandara, Two months (Full time)
5. S. Meegahakumbura, One month ((Full time)

7.2.2 FOOD SCIENCE AND NUTRITION

Project Leader: Dr. Ruvini Liyanage (*Research Fellow*)

Description of the Project

This project commenced activities in January 2011. The aim of this project is to uplift the nutritional status of people in Sri Lanka. Studies involve conducting research on various food items to ensure their quality as well as studying the effects of various types of diet on the body chemistry and to explore the links between nutrition and well-being. At present, non-communicable diseases (NCDs) are the leading cause of death in Sri Lanka. Major NCDs such as cardiovascular diseases and diabetes are caused by life style related factors such as, poor diet, lack of exercises etc. Thus, prevention of the onset of these diseases is important and it is vital to identify a food-based approach within a context of Sri Lankan food habits and cultural practices.

To address these problems, two separate studies were conducted to investigate the effect of processed cowpea and banana blossom incorporated experimental diets on lipid and glucose metabolism in animal experimental model. Further, a probiotic soy yoghurt was developed as a vehicle for vegetarians to improve gut health.

Research Expertise: Prof. S.A. Kulasooriya
Research Assistant: Ms. O.S. Perera
Technical Assistant: Ms. Iranganie Thumpela
Collaborators: Dr.JanakVidanaarachchi, University of Peradeniya
Dr.Barana Jayawardana, University of Peradeniya

Postgraduate students

1. O.S.Perera, Research Assistant, reading for a M.Phil degree in Food and Nutrition, Postgraduate Institute of Agriculture, University of Peradeniya. Thesis title - *Hypocholesterolemic and hypoglycemic effect of cowpea incorporated experimental diets in Wistar rats*

2. H.K.S.N.S Gunarathne, Reading for a MSc in Biotechnology, Postgraduate Institute of Science, University of Peradeniya

Students trained during 2013

Volunteer research assistants - Ms.Nasrin Sarabdeen (1 month)

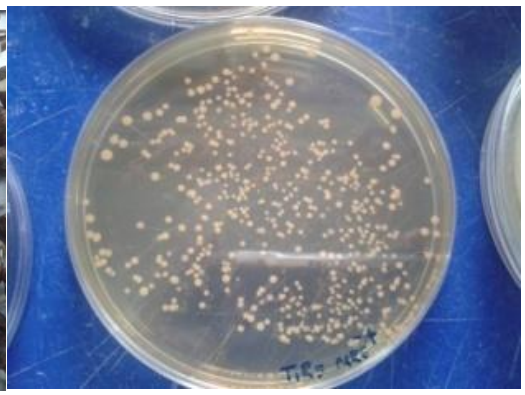
Supervision of final year undergraduate students

Ms. Pabodha Weththasinghe: Final year student, Faculty of Agriculture, University of Peradeniya (6 months)

Ms.Sharanya Gunasegaram: Final year student, Faculty of Agriculture, University of Peradeniya (6 months)

Ms. B.G.S. Jayarathna: Final year student, Faculty of Agriculture, University of Peradeniya (6 months)





7.2.2.1 Hypocholesterolemic and Hypoglycemic effect of processed cowpea (*Vigna unguiculata* L. Walp) incorporated experimental diets in Wistar rats (*Rattus norvegicus*)

O. Perera[1], P. Weththasinghe[2], B.C. Jayawardana[2], J.K. Vidanarachchi[2], R. Liyanage[1]

[1]Food Science Project, Institute of Fundamental Studies, Kandy, [2] Department of Animal Science, University of Peradeniya.

Introduction

At present, the growing prevalence of NCDs in individuals is a worldwide health problem. Cowpea is one of the major legumes which are potential agents of reducing serum lipids and glucose. Apart from the phyto-nutrient components, many other factors such as the form of food, cooking and processing affect the response since it has been shown that cooking modulates the nutritional and biochemical parameters of food[1]. Thus, in this study the hypocholesterolemic and hypoglycemic effect of boiled MI 35, boiled Bombay cultivar and sprouted Bombay cultivar were investigated in comparison with raw cowpeas of the same cultivars.

Objectives

General Objective

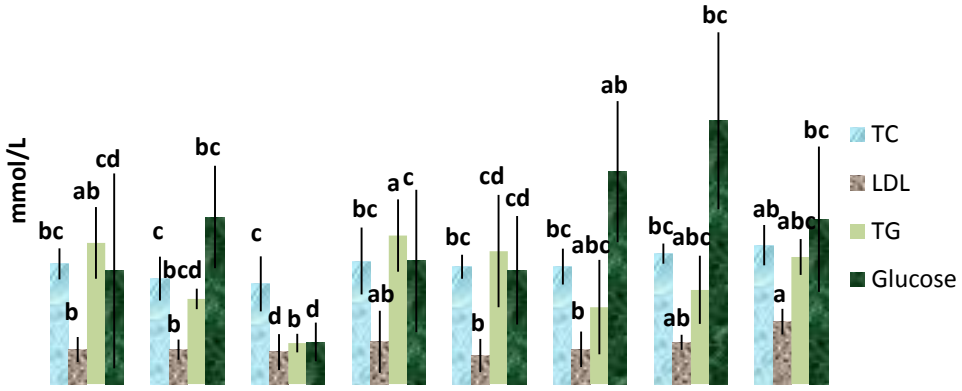
To investigate the hypolipidemic and hypoglycemic effect of raw and processed cowpea incorporated experimental diets in Wistar rats.

Specific Objectives

To investigate the effect of feeding raw, cooked and sprouted cowpea powder incorporated experimental diets on:

Serum lipid concentrations
Serum glucose concentration
Serum antioxidant capacity
Cecal bacterial population, cecal pH, cecal weight and fecal weight
Body weight, liver weight and kidney fat mass

Results



Values are means ± standard deviations, Means bearing different superscripts are significantly different (p<0.05), BOF=HFD + 20% Bombay cowpea powder, MIF=HFD + 20% MI 35 cowpea powder, WAF=HFD + 20% Waruni cowpea powder, DAF=HFD diet + 20% Dawala cowpea powder ,BBF=HFD with + boiled Bombay cowpea powder, BMF=HFD with + boiled MI35 cowpea powder and SBF=HFD with + sprouted Bombay cowpea powder , HFD=HFD + casein powder

Figure 1: Serum lipids and glucose concentration in rats at the end of 6 weeks feeding period

Serum total cholesterol, non-HDL cholesterol and triacylglyceride and glucose concentrations in WAF fed group were significantly lower ($P < 0.05$) than HFD fed group and this was accompanied by significantly higher serum antioxidant activity in WAF group. Serum LDL cholesterol level in BOF, MIF, BBF and BMF diets were significantly lower ($P < 0.05$) than HFD fed group. There was no significant difference in plasma lipids and glucose concentrations among raw and processed cowpea incorporated diets fed groups. Raw and processed cowpea produced significant hypoglycemic and hypolipidemic effects in Wistar rats.

7.2.2.2 Investigating*in vivo* hypolipidemic, hypoglycemic and antioxidative capacity of Banana Blossom incorporated experimental diets in rats fed with cholesterol

S. Gunasegaram[1], J.K. Vidanarchchi[2], O. Perera[1], B.C. Jayawardana[2], R. Liyanage[1]

[1]Food Science Project, Institute of Fundamental Studies, Kandy, [2]Department of Animal Science, University of Peradeniya.

Introduction

Blossom of the banana plant (*Musa acuminate* Colla) is often consumed as a vegetable in many Asian countries such as Sri Lanka, Malaysia, Indonesia and the Philippines. In Sri Lanka, more than 32 million the banana bunches are produced annually (Department of Census and Statistics, 1998, Agricultural Statistics, Sri Lanka). Banana blossom is a popular dish in Sri Lankan cuisines. It is consumed as a curry as well as a boiled or deep fried salad with rice and wheat bread. Despite the absence of data on the dietary fiber content and composition of the banana blossom, it is generally valued as a fiber-rich source[1]. Dietary fiber in vegetables helps to protect against cardiovascular diseases by improving blood lipid profiles, lowering blood pressure and reducing indicators of inflammation. Food components with antioxidant properties may prevent the cardiovascular diseases by inhibiting the oxidative damage to LDL-cholesterol. In a previous study, banana blossom extracts have shown higher antioxidant capacity and antioxidant potentials of alcoholic extracts of banana as manifested by the elevation of reduced glutathione (GSH) content. The findings suggests that the unripe banana extracts had a higher antioxidant potency than the ripe one. The current study was conducted with the aim to investigate the banana blossom incorporated experimental diets on lipid and glucose metabolism and antioxidant capacity in rats.

Objectives

General Objective

To investigate the health benefits of banana blossom incorporated experimental diet.

Specific Objectives

To investigate the effect of Banana blossom incorporated experimental diets on:

- Serum cholesterol (total cholesterols, HDL cholesterol, LDL cholesterol) and triacylglycerol level.
- Serum glucose concentration
- Serum antioxidant capacity
- Cecal microflora composition
- Liver weight, body weight, cecal weight and kidney fat index

Results

Final body weight in the 5% cholesterol+ 21% banana blossom powder was significantly ($P < 0.05$) lower than the 5 % cholesterol diet and not significantly different compared to the control diet. The fecal weight in 5% cholesterol+ 21% banana blossom powder was significantly ($P < 0.05$) higher than other two groups.

Serum total cholesterol, non-HDL cholesterol, glucose content and GOT were significantly lower in rats with banana blossom diet than 5% cholesterol diet (CD) fed group. Lower serum lipids and glucose level in banana blossom fed rats accompanied by higher fecal weight, higher *Lactobacilli* and *Bifidobacterium* population compared to high cholesterol diet (HCD) fed group. Lower serum GOT

level in banana blossom fed rats showed the reduction in oxidative stress induced by high cholesterol diet. However, there was no significant difference in serum antioxidant activity among three groups. Banana blossom incorporated experimental diet modulated the serum lipid and glucose content and cecal microflora in Wistar rats.

Table 1.Serum Total Cholesterol, High Density-lipoprotein-cholesterol (HDL-cholesterol), Non-HDL- cholesterol and glucose concentrations (mmol/L), GOT (△ A /min) and antioxidantactivity (AOA µmol/L) in rats at the end of the experiment.

	C	5% CD	
Total Cholesterol	1.1604 ± 0.28 [b]	1.6787 ± 0.20 [a]	1.3235 ± 0.09 [b]
HDLcholesterol	0.6850 ± 0.18 [a]	0.4851 ± 0.02 [b]	0.4910 ± 0.07 [b]
Non-HDL-cholesterol	0.4754 ± 0.26[c]	1.1935 ± 0.18 [a]	0.8320± 0.10 [b]
Glucose	3.3626 ± 1.01 [a]	3.5352 ± 1.40 [a]	2.9473 ± 0.31 [b]
GOT	1.0784± 0.31 [b]	6.4024±3.988 [a]	0.7486 ± 0.42 [b]
Antioxidantactivity	600.313±78.619[a]	437.413± 8.010[a]	513.908 ± 91.388[a]

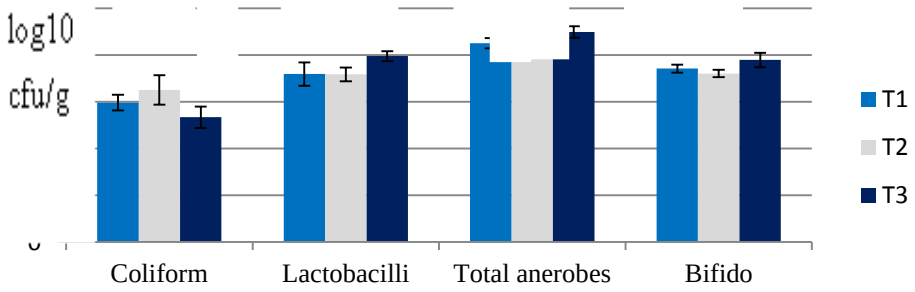


Figure 2. Cecal bacterial population of rats fed experimental diets for 4 weeks [log_{10}cfu/g content]

7.2.2.3 Development of Probiotic Soy Yogurt

B.G.S Jayarathna[1] , H.K.S.N.S. Gunarathne[1], B.C. Jayawardana[2], J.K. Vidanarachchi[2], G. Senevirathne[1], R. Liyanage[1]

[1]Food Science Project, Institute of Fundamental Studies, Kandy, [2] Department of Animal Science, University of Peradeniya

Introduction

The demand for alternatives to cow milk is growing due to problems with allergenicity, desire for vegetarian alternatives, lactose intolerance and high price and scarcity of cow's milk. Also, the consumers today are highly concerned about the transfer of harmful substances through cow's milk such as herbicides, pesticides and dioxins. Additionally many religious and cultural taboos are concerned with the consumption of protein-rich animal food. Therefore, there is an increasing interest towards vegetable protein-derived substitutes. Among the vegetable protein sources, soy protein has been ranked superior to most others. Soy milk is concerned as an alternative to cow milk and has immense health benefits. Since soy yogurt has high nutritional value, low cost of production[1]and improved flavor, lactic fermentation of soy milk into soy yogurt is worthwhile. Studies have shown that soymilk is a good substrate for some *Lactobacilli* and *Bifidobacteria*. Thus, the aim of this study was to develop a total vegan probiotic whole soy yogurt.

Objectives

General Objective

To develop a probiotic vegan yogurt

Specific Objectives

- Develop soy yoghurt incorporated with *Bifidobacteria* and *Lactobacillus* as probiotics
- Investigate the possibility of replacing gelatin with a plant based stabilizing agent

Results

Soy milk with agar agar stabilizer can be used to produce a 100% vegan yogurt. According to sensory analysis, incorporation of probiotic *Bifidobacteria* to soy yogurt could improve the quality of the product. Soy yogurts are effective to be used as probiotic carrier food because recommended probiotic concentration level of 10^6 to over 10^7 or 10^8 can be achieved with *Bifidobacteria* when used in soy yogurt. The highest viable bacterial counts of total lactic acid bacteria and *Bifidobacteria* were observed at the 7^{th}day of storage and were significantly higher than the viable counts of a probiotic cow milk yogurt.

Storage Time(Days)	Total lactic acid bacteria (cfu/mL)	Bifidobacteria (cfu/mL)
1	8.63^b	8.47^b
7	8.85^a	8.87^a
14	8.66^b	8.60^b

7.2.3 FUNCTIONAL FOOD PRODUCT DEVELOPMENT

Project Leader: **Dr. Viduranga Waisundara** (*Research Fellow*)

Description of the Project

The research project on Functional Food commenced in April 2013.The project work focuses on identifying and developing functional food which will be beneficial to consumers in Sri Lanka for health and wellness purposes. Functional food have been defined as food products which have a potentially positive effect on boosting the health and initiating disease prevention – both aspects which are beyond the basic nutritive needs expected to be provided through food consumption. Although all food products may be considered as functional since they provide varying amounts of nutrients and energy to sustain growth or support vital processes, functional foods differ in these characteristics since they are generally considered to reduce the risk of disease or promote optimal health.

The primary objective of this research project is to identify functional food products which are already part of the local diet and may be vital in the prevention of diseases among the local population. A special emphasis is laid on functional food which may have an effect on the prevention or control of diabetes – a disease which has clear ties with the consumption of food and dietary practices

Analysis of the Antioxidant Capacity of Leafy Vegetables and Herbs in Sri Lanka

Oxidative stress has been known to be the root cause of many diseases such as cancer, cardiovascular disease and diabetes. Thus, antioxidants have been touted as a potential remedy to prevent the occurrence and instigation of these disease conditions. A study was conducted on identifying the antioxidant potential of leafy vegetables and herbs such as *Coccinia grandis* (‘Kowakka’) *Costus specious* (‘Thebu’) and *Gymnema sylvestre* (‘Mas Bedda’) which have been consumed for generations as part of the regular Sri Lankan diet or for medicinal purposes. For this purpose, the Oxygen Radical Absorbance Capacity (ORAC) assay was established for the quantification.This assay expresses the antioxidant capacity of extracts in Trolox Equivalents (TE) which is essentially a vitamin E analogue, and uses 2,2'-azobis(2-amidinopropane) dihydrochloride (AAPH) as the radical generator.The ORAC assay is structurally sensitive and has a better correlation with the amount antioxidant compounds present in the prepared extracts.The study was able to add scientific value by systematically determining the antioxidant properties of the selected plants.

Fermented Functional Food with Antioxidant Properties

Fermented food products are not regular items of the Sri Lankan diet despite scientific evidence supporting their benefits of consumption. A study was conducted on a fermented tea which may be easily prepared on a domestic scale. This tea is commonly prepared using Chinese black tea which has been popularly known to have a high antioxidant capacity. However, Chinese black tea is hard to obtain locally as compared with the Sri Lankan black tea, which is more readily available. Thus, for the first time, the antioxidant properties of the fermented tea prepared using Sri Lankan black tea was elucidated and quantified using the ORAC assay.

Volunteers: Miss M.I. Watawana (PGIA) (September 2013 onwards for 6 months)
Miss N.N. Jayawardena (PGIA) (November 2013 onwards for 6 months)

7.2.3.1 Evaluation of the Antioxidant Activity of Traditional Medicinal Herbs from Sri Lanka

V. Y. Waisundara*, M. I. Watawana, N. N. Jayawardena

Functional Food Product Development Project, Institute of Fundamental Studies, Kandy

Introduction

Sri Lanka has been gifted with a wide assortment of plant species due to its location in the tropics as well as the variability of climatic zones. For generations, the plants have been consumed as cures for ailments, disease prevention or simply for the purpose of maintaining health and wellness. Since a successful cure for diseases such as diabetes or cancer are virtually nonexistent in the Western medicinal equivalents, the tendency for individuals contracted with these diseases to seek alternative remedies has been observed to be on the rise[1].Compared with traditional Indian or Chinese herbal medicinal practices, the Sri Lankan counterpart has more unexplored territories which are open for scientific research. As a step towards adding the scientific background to some of the commonly used herbal medicines of Sri Lanka, this study was carried out to investigate the antioxidant activity of the following 18 herbs which are mostly used for anti-diabetic purposes[2]:

- *Adhathoda vasica* (Adhathoda)
- *Alternanthera sessilis* (Mukunuwenna)
- *Amaranthus viridis* (Kura Thampala)
- *Annona muricata* (KatuAnoda)
- *Artocarpus heterophyllus* (Kos)
- *Asparagus racemosus* (Hathawariya)
- *Centella asiatica* (Gotu Kola)
- *Coccinia grandis* (Kowakka)
- *Costus specious* (Thebu)
- *Desmodium gangeticum* (Undupiyaliya)
- *Gymnema sylvestre* (Masbadda)
- *Ipomoea aquatica* (Kang Kung)
- *Mimosa pudica* (Nidikumba)
- *Momordica charantia* (Karavila)
- *Psidium guava* (Pera)
- *Sesbania grandiflora* (Kathurumurunga)
- *Solanum americanum* (Kalukammeriya)
- *Wattakaka volubilis* (Kiri Anguna)

These herbs were selected primarily because only their leaves are being used for the treatment of the disease.

Objective

This study was designed to evaluate the antioxidant activity of 18 selected Sri Lankan medicinal herbs which are commonly used as anti-diabetic remedies.

Methodology and Results

The herbs were intensively sun-dried for 8 hours and ground to powder. Twenty milliliters of water at 60 ^{0}C was added to one gram each of the powders to prepare a decoction and allowed to cool to 25 ^{0}C. The mixtures were centrifuged and the supernatants were separated. The total phenolic contents, Oxygen Radical Absorbance Capacity (ORAC) values and DPPH radical scavenging activities were analyzed. According to the results obtained it was found that the following five herbal extracts had the highest antioxidant activity:

Coccinia grandis (Kowakka) | *Costus specious* (Thebu) | *Psidium guava* (Pera) | *Desmodium gangeticum* (Undupiyaliya) | *Mimosa pudica* (Nidikumba)

7.2.3.2 Evaluation and comparison of the antioxidant properties of Kombucha Teas

V. Y. Waisundara, M. I. Watawana, N. N. Jayawardena

Functional Food Product Development Project, Institute of Fundamental Studies, Kandy

Introduction

Kombucha tea is a functional food traditionally prepared using sugared Chinese black teafermented by a mixed culture of bacteria and yeasts. Fermented functional foods are not regular components of the Sri Lankan diet. Thus, kombucha tea could be considered as a potential product to fill this void. The health benefits of the kombucha tea such as the alleviation of arthritis, cancer and inflammations have been closely associated with its antioxidant potency. Most of the studies on antioxidant activity have been carried out on kombucha tea prepared from Chinese black tea (CBT). However, there have been no investigations to date on the antioxidant properties of kombucha tea prepared using Sri Lankan black tea (SLBT).

Objective

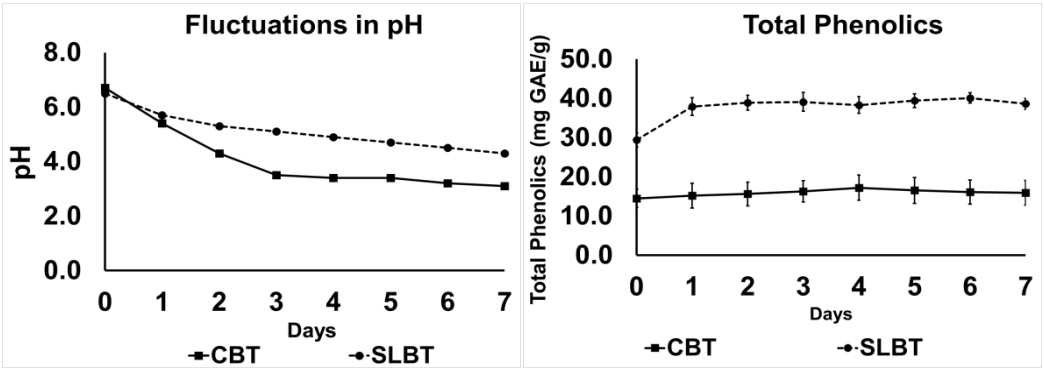
To systematically evaluate and compare the antioxidant activity of two kombucha teas prepared from CBT and SLBT.

Methodology andResults

LapsangSouchong Chinese Black Loose Leaf Tea was obtained from Suzhou, China while the SLBT was locally obtained. Approximately 2.5% (w/w) of the two teas were added to boiling water and allowed to infuse for 5 min. Sucrose (5%, w/w) was dissolved in the hot teas and left to cool until room temperature. Tea (200 ml) was poured into sterile jars and inoculated with 3% (w/v) of the freshly grown starter culture. Daily sampling was carried out for 7 days to quantify the ORAC[1], total phenolic content[2] and pHvalues. These parameters were also measured in both teas prior to addition of the starter cultures (considered as day 0). IBM SPSS Statistics version 21.0 for Windows was used for the statistical analyses. Results are calculated and expressed as mean ± standard error mean (SEM) of≥3 independent analyses. *P* values of>0.05 were considered to be significant.

Figure 1. Kombucha teas during fermentation prepared from (A) Chinese black tea and (B) Sri Lankan black tea on day 7

Images of the two kombucha teas are shown in Figure 1. As shown in Figure 2, the pH of both teas decreased during the period of monitoring owing to the production of ethanol during the fermentation process. The total phenolic content of SLBT was observed to be statistically significantly higher than CBT ($P \leq 0.05$) throughout the period of monitoring. This was in correlation to the ORAC values where SLBT displayed a statistically significantly higher ($P \leq 0.05$) antioxidant potential than CBT. In conclusion, kombucha tea prepared from SLBT had the higher antioxidant potential than CBT indicating it to have better health benefits as a fermented functional food.



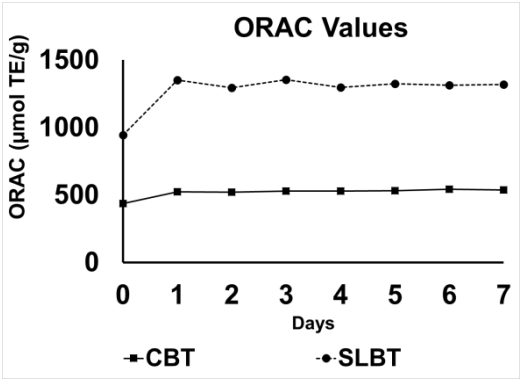


Figure 2. (A) pH (B) total phenolic content and (C) ORAC values of CBT and SLBT. The error bars represent the SEM.

7.2.4 MICROBIAL BIOTECHNOLOGY

Development of biofilmed biofertilizers (BFBFs) for applications in agriculture

Project Leader: **Prof. G. Seneviratne** *(Research Professor)*

Description of the Project

There is a growing concern about food security and sustainability of agricultural production in the world; however there are limited attempts to understand the determinants of stability in agroecosystems, particularly in the tropics. Conventional agricultural practices have generally created adverse environmental conditions stressful to the biota, reducing biodiversity and soil fertility, because biotic and abiotic stresses in the environment transfer organisms from live stage to dormant stage (Seneviratne et al., 2013). It has been reported that the functional stability of the ecosystems in the face of environmental stress is strongly influenced by the initial evenness of taxa of the microbial communities, because even rare bacterial taxa have been observed to be disproportionately active relative to common bacterial taxa. When these communities are highly uneven or if there is extreme dominance by one or a few species under adverse soil conditions, their performance is less resistant to environmental stress, and hence that reduces microbial functions and negatively affects ecosystem functioning. Therefore, the collapse of microbial communities, particularly N_2 fixers mainly due to chemical N inputs may lead to reduced plant diversity, as indicated by the study of van der Heijden et al. (2006), and agro-biodiversity in general. This tends to weaken the interactions among biotic and abiotic components, consequently breaking the delicate balance of the ecosystem. It has now been confirmed that even in natural ecosystems like forests, soil microbes play an important role in determining plant species diversity. The N_2 fixers play a key role in the growth and persistence of effective soil microbial communities by supplying nitrogen through N_2 fixation. Disturbances to the ecosystem balance, caused by stress factors promote negative environmental impacts on agriculture such as pests and pathogens, and also reduce internal biological actions and cycles, resulting in low decomposition and hence accumulation of toxic compounds, adversely affecting sustainability. This eventually leads to degradation of the agroecosystems.

As a recent development in biofertiliser research, fungal-rhizobial biofilms have been developed *in vitro* from microbial communities and these are now termed biofilmed biofertilisers (BFBFs, Seneviratne et al., 2008). The BFBFs showed increased N_2 fixation, mineral nutrient release in the soil, organic acid and plant growth hormone production, and supported enhanced plant growth, yield and stress tolerance, compared to mono- or mixed cultures of the component microbes without biofilm formation. Incorporation of other diazotrophs like *Azotobacter* species together with rhizobia in the community as higher order biofilms is helpful for rhizobia to fix N_2, because most rhizobia lack the gene *NifV*, responsible for homocitrate synthase, which is possibly shared with the rhizobia by the other diazotrophs. The positive role of the BFBFs on the improved plant growth and yield under reduced rates of chemical fertiliser application was interpreted to be caused by the increased chemical fertiliser use efficiency, thus saving up to 50% of chemical fertiliser use. Inoculation with BFBFs maintained soil microbial diversity, even under the application of chemical fertilisers. The BFBFs revived considerably and relatively quickly microbial diversity and activity, and enhanced plant growth in a degraded tea soil through increasing biodiversity by dormancy breaking of microbial seed bank, and also bioremediation of the accumulated allelopathic phytotoxins. The increased microbial diversity contributed to a natural biocontrol of a pest on the tea soil. The BFBFs also showed reduced N_2O emission from the tea soil. In this manner, the BFBFs could restore ecosystem functioning

through altered microbial diversity which would help reinstate sustainability even in mono-cropped agriculture with chemical inputs.

Sustainability in terrestrial ecosystems is an outcome of a complex, non-linear interaction among microbes, plants,

animals, including humans and the soil and atmosphere, and hence it is a harmonization among soil and atmospheric sciences, entomology, pathology and all other plant and animal sciences. Sustainability is improved through enhanced biodiversity and ecosystem functioning. However, it is pity to see the absence of this amalgamation in nature, in the man-made sciences. For example, in the field of soil sciences, it is frequently noticed that some or perhaps majority of soil chemists do not know or care much about the importance of soil microbiology and vice versa. This is mainly due to lack of interdisciplinary or trans-disciplinary coordination (multidisciplinary nature) of our scientific research and development process. This is an important issue that should be addressed and rectified immediately by us.

Research summaries

Developing BFBFs for coconut

The objective of this study is to develop a BFBFs formulation to coconut nurseries. Initially, coconut planted to a virgin soil in a nursery was uprooted and fungi and bacteria were isolated from the roots, according to protocols developed by the Molecular Biotechnology Unit (MBU), IFS. Isolated microbes were then tested for pathogenicity. Bacteria were then grown in Combined Carbon Media (CCM) for isolation of nitrogen fixers. The isolated bacteria were evaluated for nitrogenase activity (ARA) using GC. Then the biofilms were developed and screened. The selected biofilms were applied to four nurseries in Kurunegala, which are under the Kurunegala Plantations Limited.

Developing BFBFs for forest tree nurseries

In an experiment on the development of BFBFs for planted forest tree seedlings on grasslands, *Macaranga indica, Bhesa ceylanica, Sympocos cochinchinensis* and *Eugenia bracteata*, four native trees growing in Knuckles conservation forest were used to isolate rhizoplane microbes. In this, 32 bacteria and 13 fungi were isolated and screened. Out of the selected microbes, 6 fungal-bacterial biofilms were developed and applied to nursery and field trials.

Validating the effect of BFBFs under farmers' field conditions

Evaluation of yield and growth parameters of maize, cowpea, ground nut and green gram with BFBFs application in farmer field experiments at Mahawa, Galgamuwa and Anamaduwa were completed in collaboration with the Provincial Department of Agriculture, Wayamba. Further, farmer field trials were concluded for testing BFBFs with maize, green gram and soybean at Anuradhapura, Mahiyangana and Thissamaharama, in collaboration with Plenty Foods (Pvt.) Ltd. The BFBFs were tested for maize and rice at Padiyathalawa in farmers' fields.

Evaluation of yield and growth parameters of maize, rice, tomato, chilli and cabbage with BFBFs application in farmer field experiments at Ampara, Thalathuoya and Mahiyangana were completed.

These studies were done in larger plots of 9 m^2 under framers' field conditions. At all locations, 100% recommended chemical fertilizer (CF) application was compared with 50% CF + BFBFs. It was found

that the 50% CF + BFBFs gave equal or relatively higher seed yields, compared to 100% CF. This has both CF reduction and yield increase benefits.

A study is being conducted for improving the existing BFBF for maize by replacing its fungal species. This is important for improving the efficiency of BFBFs under low soil phosphorus levels.

Visiting Research Professor: Prof. S.A. Kulasooriya
Research Assistants: U.V.A. Buddhika, S. Ekanayake, M. Seneviratne
Senior Staff Technical Officers: R.C.K. Karunaratne, A. K. Pathirana

7.2.4.1 Can developed microbial biofilms mitigate agro-biodiversity loss?

H. M. L. I. Herath, G. Seneviratne, N. Senanayake

Microbial Biotechnology Unit, Institute of Fundamental Studies, Kandy

Biodiversity is a key to maintain functioning of ecosystem and its existence. Loss of biodiversity may ultimately threaten the life and its furtherance. Modern agriculture has been one of the greatest causes for biodiversity degradation (Jackson et al. 2005). Conservation of remaining agro-biodiversity has been a major issue at present. It has also been argued that available conservation measures are insufficient to halt biodiversity loss (Kleijnet al. 2011). Thus, novel approaches and concepts should be tested. As a recent development in microbiology, fungal surface attached bacterial communities or biofilms are being studied for various biotechnological applications (Seneviratneet al. 2008). It has been reported that the introduced biofilms enhance the ecosystem functioning which has a direct link to biodiversity. The present study was therefore conducted to investigate the effect of the introduced biofilms on regenerating the lost biodiversity in the soil of agroecosystems. For that, soils collected from an agricultural field were separately treated with a developed biofilm, its' mono cultures, nutrient solution used for culturing the microbes and distilled water in a pot experiment. After three months, the pots were evaluated for plant and microbial species richness, nitrogenase activity, and some soil parameters. It was observed that the biofilm added soil pots harboured significantly higher bacterial, fungal and plant species richness, soil nitrogenase activity, organic carbon, available ammonium and nitrate than those of its mono culture treatments. From the present study, it is clear that inoculation from the developed microbial biofilms positively influences microbial and plant diversity and soil quality parameters. Thus, the developed microbial biofilms can be used as a novel biotechnological tool to mitigate biodiversity loss in agroecosystems and perhaps in natural ecosystems.

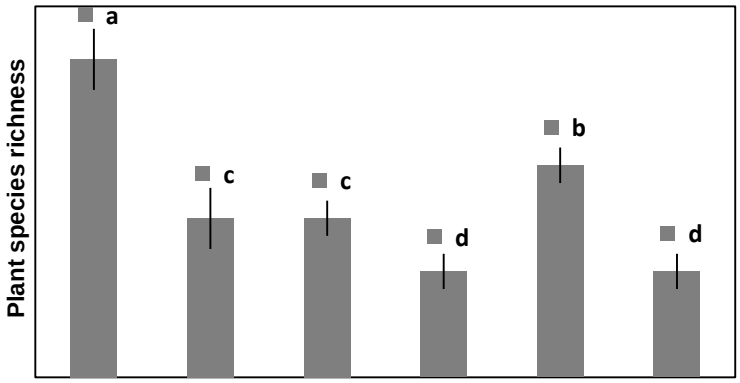


Fig. 1.Plants species richness in microbial biofilm added, fungal mono culture (*Colletotrichum* spp.) added and bacterial monocultures (*Rhizobium* spp., *Bradyrhizobium* spp., *Acetobacter* spp. *Azotobacter* spp.) added soil pots, after one month of treatments application. Different letters on the columns show significant differences at 5% probability level, whereas the columns with the same letter are not significantly different at the same probability level. Vertical bars on the columns show standard errors.

Collaborators

1. Prof. Ivan Kennedy, University of Sydney, Australia.

Human Resource Development

M.Phil Degree completed – U.V.A. Buddhika (Research Assistant)

Title of Thesis: *Biofilms with nitrogen fixing bacteria and fungi: a novelbiofertilizer technology for sustainable maize (Zea mays L.) cultivation*. Postgraduate Institute of Science (PGIS), University of Peradeniya.

Registered for Ph.D/M.Phil, PGIS, University of Peradeniya

1 A. Hemagamage and D. Sinhalage – Ph.D (Uva Wellassa University)
2. R.D.A. Gunasekara- M.Phil. (University of Ruhunu) Research projects (on-going)

B. Sc research projects (completed)

1. Priyangika Manel (University of Sabaragamuwa)

2 Subashini Rajapaksha, (University of Rajarata)
3 Nipuni Chandrasiri (University of Rajarata)
4 Piyumi Wijepala (University of Uwa Wellassa)

Volunteers trained

S. Gunaratne (February 2012- to date), S.U. Welmillage (December 2012- to date),

L.A.M.A.N. Abeyrathne, W.A.D.I. Perera (Hardy), W.A.M.M. Wijesooriya (April 2013 – to date), A.M.Y.Y. Eriyagama (March 2013 – to date)

7.2.5 NATURAL PRODUCTS

Project Leaders: Prof. U.L.B. Jayasinghe *(Research Professor)*

Prof. N.S. Kumar *(Research Professor)*

Description of the Project

Secondary metabolites produced by plants, fungi, other micro organisms, marine organisms and lichens are better known as Natural Products. Research activities in the Natural Products project have been focused on the chemistry and bioactivity of secondary metabolites from plants, fungi (including endophytic fungi) and edible fruits of Sri Lanka. Identification of polyphenols found in tea, fruits and edible spices by LC-MS is also being carried out. The overall objectives of these projects is the identification bioactive extracts and compounds from natural sources, as potential resources for control of human and plant diseases.

The bioactivities of extracts and compounds are being assessed using bioassays; DPPH (2,2'-diphenyl-1-picrylhydrazyl) assay to detect the presence of natural antioxidants; the brine shrimp (*Artemia salina*) lethality assay to detect cytotoxicity; the lettuce (*Lactuca sativa*) seed germination assay to detect the presence of phytotoxic compounds and the TLC bioautography method to detect the presence of antifungal compounds. Enzyme assays to detect the presence of naturally occurring □-amylase, □-glucosidase and lipase inhibitors respectively, are being used in the recognition of natural sources which may be of importance in the identification of extracts/compounds which can find application in the formulation of health and food related products. These inhibitors interact with specific enzymes and block their activity towards the corresponding natural substrate. Naturally occurring inhibitors are biochemical tools that have potential utility in the treatment of diseases. For example, □-amylase, □□glucosidase and lipase inhibitors are drug targets for the treatment of diabetes, obesity and hyperlipaemia, and may eventually be of use in drug research leading to the development of new products.

The accidental discovery of the first antibiotic Penicillin from the mould *Penicillium notatum* led to the age of antibiotics and research on fungal metabolites. Endophytic fungal strains produce natural products that are either identical or closely related to those produced by the host plant. A well known example is the production of Taxol, an anti-cancer drug obtained from the Pacific Yew tree *Taxus brevifolia*, which was also produced by the endophytic fungus *Taxomyces andreanae* from the bark of *T. brevifolia*. Isolation of endophytic fungal strains from some Sri Lankan fruits has resulted in the isolation of some unusual bioactive metabolites.

Collaborators

1. Dr. W.A.R.T. Wickramarachchi, HORDI, Gannoruwa
2. Dr. K.A.N.P. Bandara, HORDI, Gannoruwa
3. Prof. B.M.R. Bandara, Faculty of Science, University of Peradeniya
4. Prof. Vasanthi Thevanesam, Faculty of Medicine, University of Peradeniya
5. Dr. Kumudu Perera, Faculty of Medicine, University of Peradeniya
6. Prof. Deepthi Yakandawala, Faculty of Science, University of Peradeniya
7. Prof. Y. Fujimoto, Tokyo Institute of Technology, Japan
8. Prof. N. Kuhnert, Jacobs University Bremen, Germany

Research Scientist: Dr. K.G.N.P. Piyasena *(NSF Project)*

Research Assistants: Ms. H.M.S.K.H. Bandara
Ms. K.G.E. Padmathilake *(until Sept. 2013)*
Ms. G.G.E.H. De Silva
Ms. H.R.W.M.D.P.K Niyangoda *(until 17.04.2013 - NSF project)*
Ms. A.G.D.D. Silva *(until Oct. 2013)*
Ms. R.M.W.C.K. Karunarathna *(from 17.04.2013 – NSF project)*
Ms. T. Sritharan *(from 15.05.2013 – NRC project)*

Senior Staff Technical Officer: Mr.D.S. Jayaweera

7.2.5.1 Edible Fruits: Chemistry and Bioactivity

G.G.E.H. De Silva, R.M.W.C.K. Karunarathna, D. Niyangoda, D.C. Gunawardena, N.S. Kumar, U.L.B. Jayasinghe

Natural Products Project, Institute of Fundamental Studies, Kandy.

Introduction

Fruits have been consumed for centuries by animals and humans and are a reliable source of non-toxic and environmentally friendly bioactive compounds. Most of the studies on edible fruits are limited only to their nutritious value. Consumption of fruits has been associated with a reduced risk of chronic diseases and the reduction of functional declination associated with aging. Bioactivity studies of compounds specific to tropical fruit plants have led to the discovery of new chemical entities with interesting bioactivities and reduced toxicity. The presence of inhibitors of carbohydrate hydrolyzing enzymes, e.g. α-amylase, in plant derived foods is of immense importance in the control of blood glucose level in patients with type II diabetes. Antioxidants help to prevent free radical induced oxidative stress and help to either prevent or delay diseases related with aging. Fruit extracts that display antifungal activity could lead to the isolation and identification of environmentally friendly pesticides and antifungal agents.

Objectives

Evaluation of the bioactivities of some edible fruits in Sri Lanka with special reference to antifungal, antioxidant, cytotoxic, phytotoxic and enzyme inhibitory (α-amylase and lipase) activities.

Methodology and Results

The popular edible fruits *Aegle marmelos* (Sinhala:Beli), *Anacardium occidentale* (Kajupuhulan), *Averrhoa bilimbi* (Bilin), *Citrullus lanatus* (Peni Komadu), *Garcinia cambogia* (Goraka), *Limonia acidissima* (Divul), *Manil karazapota* (Sapodilla), *Nephelium lappaceum* (Rambutan), *Passiflora edulis* (Pashion fruit), *Phyllanthus emblica* (Rata Nelli) were evaluated during this study. The edible part of each fruit was blended, and juice and residue were separated. Each juice was sequentially extracted with *n*-hexane and EtOAc. Residues were sequentially extracted into *n*-hexane, EtOAc and MeOH. MeOH extracts were partitioned with *n*-butanol and water. All extracts were subjected to bioassays to detect antifungal activity (TLC bioassay against *C. cladosporioides*), antioxidant activity (DPPH radical scavenging activity), cytotoxic activity (*Artemia salina* lethality assay), phytotoxic activity (inhibition of *Lactuca sativa* seed germination) and enzyme inhibitory (α-amylase and lipase) activity. Some of the bioassay results were reported in the Annual Review of 2012. Based on the results from the bioassay extracts of the fruits, *A. marmelos*, *A. occidentale*, *A.bilimbi* were selected for further studies.

In order to isolate bioactive compounds, activity-guided fractionation of fruit extracts of *A. marmelos*, *A. occidentale* (displaying α-amylase inhibition, antioxidant activity, toxicity to brine shrimp and phytotoxicactivity),(α-amylase inhibition, antioxidant activity, toxicity to brine shrimp, phytotoxic and antifungal activity) and *P. edulis* (-amylase inhibition and antioxidant activity) are in progress.

Aegle marmelos: Preliminary investigation indicated the significant antifungal and antioxidant activity in EtOAc extracts. Chromatographic separation of the EtOAc extract over silica gel, Sephadex LH-20, and PTLC furnished 12 compounds (1-12). Structures of these compounds were identified as psoralene (1), 8-methoxypsoralene (2), marmelide (3), xanthotoxol (4), 6-(dimethylallyl) umbeliferone (5), 6',7'-epoxyaurepten (6), *O*-methylhalfordinol (7), O-isopentenylhalfordinol (8), (*E*)-*N*-(2-hydroxy-2-(4-methoxy phenyl) ethyl cinnamamide (9), (*E*)-*N*-(2-(4-(3methylbut-2-enoyloxy)phenyl)-2-hydroxyethyl) cinnamamide (10), (*E*)-*N*-(2-(-4(3-methyl but-2-enoyloxy)phenyl)-2-methoxyethyl) cinnamamide (11) and cinnamic acid (12) by detail analysis of ^{1}H &^{13}C NMR and MS spectral data. According to the availability, only the compounds 3, 4, 5, 7, 8, 9, 10 and 12 were subjected to bioassays and found that the compound 4 and 5 are having significant antifungal activity against *C. cladosporioides* and compounds 4, 5, 8, 10 and 12 having significant antioxidant activity (IC_{50}< 31.25 ppm). Further the compounds 3, 4, 7 and 8 showed phytotoxicity activity (IC_{50} < 62.5 ppm). Determination of bioactivities of pure compounds is now in progress.

Results of the on-going studies indicate the presence of compounds with significant bioactivity in extracts of common edible fruits such as *A. marmelos*. The presence of bioactive compounds in these tropical fruits would be of value to the national economy.

7.2.5.2 Endophytic Fungi: Chemistry and Bioactivity

K.G.E. Padmathilake, K.G.N.P. Piyasena, N.S. Kumar, U.L.B. Jayasinghe

Natural Products Project, Institute of Fundamental Studies, Kandy

Introduction

Endophytic fungi are organisms that colonize internal plant tissues without causing apparent harm to their host. Several novel and pharmacologically active molecules have been reported from endophytic fungi. Endophytes are increasingly being identified as a group of organisms capable of providing a

rich source of secondary metabolites for use as pharmaceuticals and agrochemicals. Recently, we investigated the chemistry and bioactivity of fungi associated with *Musa* sp., and endophytes in the seeds of *Pouteria campechiana* and the leaves of *Mikania scandens*. *P. campechiana* is a golden yellow popular edible fruit of the family Sapotaceae growing in tropical countries. Some carotenoids and polyphenolic compounds have been reported from fruits of *P. campechiana*[1]. We have previously reported taxifolin, gallocatechin, quercetin and 4-hydroxyacetophenone from the seed extracts of *P. campechiana*[2].

Objective

Studies of environmental friendly bioactive compounds originating from endophytic fungi associated with fruits *Pouteria campechiana*.

Methodology and Results

*P. campechiana:*Seeds of *P. campechiana* were triple sterilized and pieces of inner parts of the seeds were placed on potato dextrose agar (PDA) plates. After 3-4 days an endophytic fungi was isolated and identified as *Penicillium purpurogenum* of the family Trichocomaceae by its microscopic and morphological characteristics. This fungus is characterized by its dark green conidia and intense red coloured soluble pigment. Molecular studies are in progress to confirm the identity of fungi. A pure culture of the fungi in PDA media was inoculated in potato dextrose broth (PDB) media in large scale (20 X 1 L conical flasks) and incubated at room temperature on laboratory shakers. Media were filtered after 4 weeks and the filtrate was partitioned with EtOAc/H_2O to give the EtOAc extract. The residue was crushed and sequentially extracted into EtOAc and MeOH (sonicator) to give EtOAc and MeOH extracts. All three extracts displayed antioxidant and phytotoxic activities while only EtOAc extracts were toxic to brine shrimps. The EtOAc extracts were chromatographed over silica gel, sephadex LH-20 and Preparative Thin Layer Chromatography (PTLC) to give two UV-active compounds 1 and 2. These compounds were identified as talaroconvolutin A (1) and 4-hydroxyacetophenone (2) by analysis of ^{1}H &^{13}CNMR data. Talaroconvolutin A has been reported from the fungus *Talaromyces convolutes* and its hydroxyl derivative has been reported from *Penicillium rubrum*. This gave further evidence that the endophyte belongs to the genus *Penicillium.* Further we have reported the isolation of *p*-hydroxyacetophenone from the seed extract of *P. campechiana.* Thus, it is significant that compound 2 was found in both in seeds as well as in the endophytic fungus *P. purpurogenum* from *P. campechiana.*

Mikania scandens: The white colored fungal strain NP-M1 was isolated (after the triple sterilization process with 70% ethanol and 5% NaOCl) from the leaves of *M. scandens,* previously identified by us as an allelopathic active plant. NP-M1was cultivated on a large scale on rice media (28 days, 100g of rice x 16) and then extracted sequentially with EtOAc and acetone. Silica gel and sephadex LH-20 column chromatography followed by PTLC on the combined EtOAc and acetone extracts gave two sesquiterpene dilactones, identified as mikanolide (1) and dihydromikanolide (2) using spectroscopic analysis (^{1}H and ^{13}C NMR, and FABMS) and by comparison with reported data. Mikanolide (1) had been previously isolated from leaves of *M. scandens* by us and shown to be a highly allelopathic active compound, with minimum inhibitory concentration of 0.083 μM/mL in the lettuce seed germination bioassay. Isolation of 1 from the leaves of *M. scandens* as well as from the endophytic fungal strain NP-M1 is of significance. The two compounds 1 and 2 had been previously reported from the plant *Mikania micrantha*[3], *M. monagasensis* and *M. cordata,* and reported to show antibacterial activity against *Staphylococcus aureus* and *β* haemolytic *Streptococcus* group A. It has also been reported that 1 and 2 enriched extracts showed DNA polymerase inhibitory activity.

7.2.5.3 Fungi associated with *Musa* sp.: Chemistry and Bioactivity

H.M.S.K.H. Bandara, N.S. Kumar, U.L.B. Jayasinghe

Natural Products Project, Institute of Fundamental Studies, Kandy

Introduction

As a continuation of our studies on biologically active natural products, we investigated the chemistry and bioactivity of secondary metabolites produced by a fungus associated with *Musa* sp.The accidental discovery of the first antibiotic Penicillin from the mould *Penicillium notatum* led to research on fungal metabolites. Several medicinally important drugs that originated from fungi are now used widely in health and crop protection. These include taxol (antitumor); mevinolin, lovastatin, pravstatin, simvastatin (cholesterol lowering); penicillin, amoxicillin, ceftrixone, cephalosporin (antibiotics); cyclosporine (immune suppressant); ergotamine (facilitate child birth), dynemicin (antitumor, antibacterial); griseofulvin (ring worm infections), pyrrolnitrin, strobulirins (antifungal). Therefore secondary metabolites from fungi have a good potential to produce bioactive compounds that will be of benefit to human beings

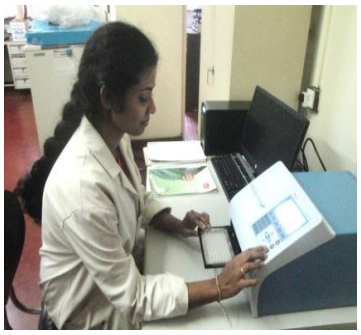
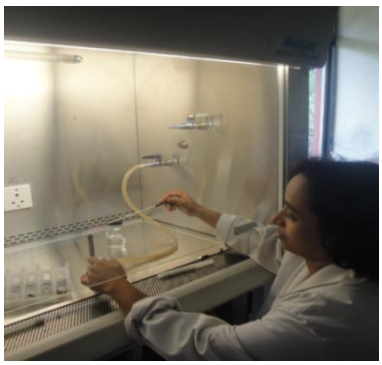
Objective

The objective of this investigation is to study the chemistry and bioactivities of the fungus isolated from the inner part of the peel of diseased *Musa sp.*

Methodology and Results

The black coloured filamentous fungus *Aspergillus niger* was isolated from the inner part of the peel of *Musa* sp by sub culturing on potato dextrose agar (PDA) medium. A pure culture of the fungus was inoculated on PDB medium in 1L Erlenmeyer flasks (x 20) and PDA medium in 15cm diameter petridishes (x 40). After 4 weeks, the PDB medium was filtered through a Buchner funnel and extracted in to *n*-hexane and EtOAc. The residual mycelium was sequentially extracted into EtOAc and MeOH (sonicator). The PDA medium was extracted into EtOAc and MeOH. All these extracts were subjected to bioassays for antifungal activity against *C. cladosporioides* by TLC bioautography method; antioxidant activity against DPPH radical using TLC bioautography method; brine shrimp toxicity against *Artemia salina* and phytotoxicity against *Lactuca sativa*. Significant phytotoxicity and brine shrimp toxicity was observed in three EtOAc extracts obtained from both PDA and PDB media. TLC analysis indicated the presence of the same compounds in the three EtOAc extracts. Hence the extracts were combined and chromatographed using a combination of chromatography over silica gel (*n*-hexane-EtOAC-MeOH), sephadex LH-20 (MeOH), reverse phase silica gel (RP) and RP-HPLC (H_2O-MeOH) to give flavasperone (1), foncesinone A (2), aurasperone A (3), aspernigrin A (4), its *N*-(2-hydroxyethyl) derivative (pestalamide C) (5) and a cephem derivative with a vinyl moiety (6). This is the first report of natural cephem derivative with a vinyl moiety. Structures of the isolates were established by analysis of ^{1}H &^{13}C NMR and MS spectral data. Foncesinone A and aurasperone A were found to be highly toxic to brine shrimp and pestalamide C was moderately toxic. None of the compounds exhibited significant activity in the phytotoxic, antifungal and antioxidant bioassays. The Cephem skeleton is present in a pharmacologically important group of compounds.




Human Resource Development

Students Registered for M. Phil/Ph.D. at the PGIS, University of Peradeniya

1. A.G.A.W. Alakolanga *(M.Phil – IFS)*: *Chemistry and bioactivity studies of Flacourtia inermis and Punica granatum*
2. H.M.S.K.H. Bandara *(M.Phil – IFS)*: *Isolation, structures and biological screening of metabolites from Aspergillus niger associated with Musa sp.*
3. G.G.E.H. De Silva *(M.Phil – IFS)*: *Chemistry and bioactivity of the secondary metabolites isolated from the fruits of Aegle marmelos and Garcinia cambogia.*
4. W.I.T. Fernando *(Ph.D. – UoP)*: *Isolation, purification and characterization of amylase and lipase inhibitors from medicinal plants traditionally used for management of diabetes and cardiovascular diseases*
5. D.S. Jayaweera *(M.Phil – IFS): Chemistry and bioactivity of some edible seeds*
6. C.L. Kehelpannala *(M.Phil – IFS): Studies on Chemical interactions between caffeine, catechins and the fungus Monacrosporium ambrosium*
7. R.M.W.C.K. Karunaratne, (*M.Sc. – UoC*): *Chemistry and bioactivity of the fruits of Averrhoa bilimbi*

8. C. Liyanarachchi *(M.Phil – UoP):* Antidiabetic activity of *Canarium zeylanicum, Osbekia octandra* and *Piper betel* and isolation of active principles
9. D. Niyangoda *(M.Phil. – IFS*): *Chemistry and bioactivity of some edible fruits*
10. K.G.E. Padmathilake *(M.Phil.-IFS*): *Chemistry and bioactivity of the secondary metabolites isolated from the seeds of Pouteria campechiana and associated endophytic fungi.*
11. A.M.D.A. Siriwardena, (*M.Phil – IFS*): "*Chemistry and bioactivity of fungi associated with the fruit of Limonia acidissima and Flacourtia indica"*
12. T. Sritharan ((*M.Phil – IFS*): *Metabolites produced by the endophytic fungi from the fruits of Carica papaya and Averrhoa carambola*

Undergraduate trainees

1. Vihanga Illeperuma, University of Peradeniya.
2. Nalin Ratnayake, Sabaragamuwa University Sri Lanka.

Volunteers

1. Tharindu Rajasooriya *(Pre University Student)*
2. Chamod Dharmadasa *(Pre University Student)*
3. Vishakya Jayalatharachchi *(I. Chem)*
4. Kanchana Ratnayake *(I.Chem)*

7.2.6 PLANT BIOLOGY

Project Leader: Dr. M. C. M. Iqbal *(Senior Research Fellow)*

7.2.6.1 Bioremediation of environmental heavy metals

Description of the Project

Heavy metals are being used in various ways for at least two millennia. However, heavy metal pollution in the environment has increased during the past few decades due to the excessive usage of heavy metals after the industrial revolution. Heavy metal pollution can arise from many sources. Industrial effluent/waste is the most common pathway by which the environment is contaminated. Once emitted, these metals persist in the environment for a long period of time, causing severe effects on the environment. Therefore, pre-treatment of effluents containing heavy metals before their discharge into the environment is necessary to reduce environmental pollution and safeguard life on earth. Although several physical/chemical conventional methods are available to remove heavy metals from contaminated systems, their usage has been limited due to high cost. Phytoremediation and Biosorption are low cost and environmental friendly biological techniques for the heavy metal removal.

There are plants which have constitutive and adaptive mechanisms for accumulating and tolerating high concentrations of heavy metals in their tissues. The use of such plants to cleanup soils and water contaminated with heavy metals is known as phytoremediation. On the other hand, certain non-living biomasses are able to remove metals from their surrounding environment by adsorbing them on to their surfaces. This technique is called biosorption.

In our project, we are carrying out researches on different living plants and non-living biological materials to determine their potential to phytoremediation and biosorption respectively, of selected heavy metals such as chromium, lead, cadmium and nickel.The kinetics and the effects of different factors on biosorption process are also being studied. Meanwhile,various desorbing solutions are being screened to remove metals from the biomaterial used for a biosorption.

From Left to Right: I. Perera, P.K.D. Chathuranga, D.M.R.E.A. Dissanayake, Dr. M.C.M. Iqbal, R.B. Hapukotuwa, S. Perera, M. Madanayake, S.K. Weerasinghe

7.2.6.1.1 Phytoremediation and Biosorption of Heavy Metals

M. C. M. Iqbal[1], P. K. D. Chathuranga[1], N. Priyantha[2], S. S. Iqbal[3]

[1]Plant Biology Project, Institute of Fundamental Studies, Kandy, [2]Postgraduate Institute of Science, University of Peradeniya, Peradeniya.[3]Department of Chemistry, Open University of Sri Lanka, Nawala.

Introduction

Our environment is continuously being polluted due to various human activities. Among various kinds of pollutants, excess levels of heavy metals have become a serious threat to life on earth. Excessive discharge and disposal of untreated industrial effluents into the environment is the major cause of heavy metal pollution. The use of available conventional decontamination techniques is limited due to their high cost. Phytoremediation and biosorption are two biological, economical and environmental friendly methods, which use living or non-living plants or plant parts to remove heavy metals from the contaminated environment.

Objectives

Our objectives are to:

1. Determine the potential of selected living/non-living plants or plant parts to remove selected heavy metals from contaminated soil and aqueous systems.
2. Identify a potential solution to desorb heavy metals from the biomass used in biosorption.

Results

Fimbristylis ovata from two different habitats (i.e. Ussangada and Pallekele) showed a similar pattern of nickel uptake from serpentine soil and the uptake was enhanced by the application of ethylenediaminetetraacetic acid (EDTA) into soil. *F. ovata* from Ussangoda habitat also removed lead from Gohagoda dump soil. Moreover, *Evolvulus alsinoides* took up nickel from a contaminated soil. Non-living *Hydrilla verticillata* removed 67% of lead in an aqueous solution using a fixed bed column. The biosorption capacity depended on the flow rate of the metal solution and the height of the biosorbent column. A complete removal of lead from *Hydrilla* was obtained using sodium carbonate. Further, non-living biomass of *Azolla pinnata* removed 97% of aqueous lead and fern *Nephrolepis*removed 90% of aqueous cadmium. An aqueous solution of sodium carbonate and EDTA desorbed lead from *Azolla* completely.

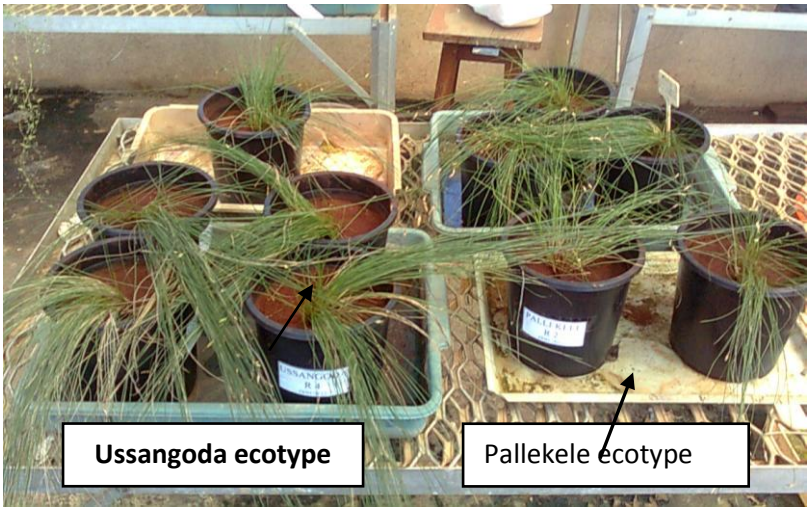


Fig. 1: Ussangoda and Pallekele ecotypes of *Fimbristylis ovata* grown in serpentine soil

Collaborators

1. Prof. Namal Priyantha, Postgraduate Institute of Science, University of Peradeniya, Peradeniya.
2. Prof. Sithy S. Iqbal, Department of Chemistry, The Open University of Sri Lanka, Nawala.

Human Resource Development

Registered for M.Phil/M.Sc.at the PGIS, University of Peradeniya

1. P. K. D. Chathuranga, M.Phil., Title: *Uptake of Heavy Metals by nonliving biomass and removal of metals by selected plant species. 2013*.
2. Rasika Dissanayake, M.Sc., Title: *Removal of Pb(II) from aqueous solutions by Hydrillaverticillata using a fixed bed column: biosorption and desorption studies,* 2013.
3. Ms. W. P. Sugandika Kumari, M.Sc. (Post Graduate Institute of Agriculture)

Undergraduate trainees

- Ms. Medha Prabashini – University of Sri Jayewardenepura, from October/2012 to February/2013 (Full time)
- Ms. Ruwini Samarakkody – University of Ruhuna, from October/2013 to date (Full time)
- H.C.D. Wijayawardhana.-. Rajarata University of Sri Lanka, Mihintale.

Volunteer: Mr. IndikaPerera

7.2.6.2 A Comparative Study on Floristic Diversity, Structure and Dynamics of Tropical Dry Mixed Evergreen Forests in Sri Lanka

Description of the Project

Approximately 54% of tropical forests in Sri Lanka are classified as tropical dry mixed evergreen forests (TDMEF). Except for a handful of grey literature, so far no comprehensive phyto-sociological studies linking with socio and agro-ecology have been done in the dry zone of Sri Lanka.

Forest vegetation is the matrix in which the biological diversity at ecosystem, species and genetic levels are developed and sustained in relation to land use, terrain, soil and rainfall heterogeneity of an area. According to the latest agro ecological region (AER) map of Sri Lanka, the entire dry zone has been divided into eleven distinct sub zones depending on rainfall, land use, terrain and major soil groups. If so, then TDMEFs in different AERs in the dry zone would also reflect this difference and exhibit distinct floristic characters. Consequently, it is apparent that the rising socio-economic impacts from development activities, human settlements, irrigation systems, agricultural projects, wild fires and alien plant introductions have extensively fragmented and degraded TDMEFs of Sri Lanka.

This research project is principally focused on identifying phyto-sociological and socio-ecological variations of TDMEFs in two different AERs (*Hurula* and *Nuwaragala*) which show different disturbance regimes. The study will select the IFS-Popham arboretum in the dry zone as another study site in which restoration options has been already adopted. Plots and transects will be used to assess phyto-sociology (in detail) and soil properties of these forest reserves. Socio ecology of local communities living in and around the above forest reserves will be studied using a questionnaire survey. It is expected that the key outcomes of this study will assist the implementation of sustainable and efficient biodiversity conservation strategy in the dry zone of Sri Lanka.

7.2.6.2.1 Phytosociology of Restored Forests in Dry Zone: A Contribution to Tropical Dry Forest Restoration of Sri Lanka

W.W.M.A.B. Medawatte[1], M.C.M Iqbal[1], M.W.S. Ranwala[2]

[1]Plant Biology Project, Institute of Fundamental Studies, Kandy, Sri Lanka, [2]University of Colombo, Sri Lanka

Introduction

Forest agrarian systems (chena/ shifting/ swidden/ slash and burn cultivation) are most ancient and widely distributed practice, which has degraded several thousand hectares of tropical dry forests in Sri Lanka. Forest recovery of these areas into its previous stage with primary forest species was delayed and forest restoration would be a challenge to forest managers and conservationists.

Although seeds are available, rapid colonization of light demanding thorny scrub thicket, creepers, weeds and grass communities (early pioneer species) suppress or delay the natural regeneration of late-successional tree species seedlings through above and below ground competition (Weerawardana 1999). Popham (1993) introduced a sustainable low cost silvicultural method combined with mango *Mangifera indica* as a nurse-tree, which assist the growth of naturally regenerated and selected emerging late-successional tree species by slashing and clearing away the early pioneer species in regular time intervals in the year.

Aim and Objectives

The aim of this study was to evaluate the effects of Popham low cost silvicultural methodon natural regeneration of dry zone primary forest species in Popham Arboretum at Dambulla in Sri Lanka. To this end, following objectives were studied;

1. Determines the effect of over-storey nurse-tree plantation on naturally regenerated dry forest tree species richness and diversity.
2. Comparison study on floristic diversity, composition and structure of restored and abandoned dry forests after chena cultivation.
3. Preparation GIS map of Popham Arboretum including all spatial and temporal details.

Results

In sample plots (0.28 ha) of the restored forest, 60 tree species were enumerated representing 53 genera, 29 families and among them 6 (10%) species are endemic to Sri Lanka while 49 (82%) were naturalized and 5 (8%) exotics. Density of nurse-trees (mango) were 50 trees/ha. Highest tree species richness was recorded in plots with nurse-trees compared to plots without nurse-trees, 51 and 38 tree species respectively. Regenerated tree species diversity among plots ranged from 1.47 and 2.58. Plots with nurse-trees, where the average tree species diversity was at the significant ($P<0.05$) highest level (2.34±0.06) compared to plots without such trees (1.98±0.12,figure 1). Pioneer thorny scrub thicket and early successional tree species of *Memecylon umbellatum, Gmelina asiatica, Maytenus emarginata, Phyllanthus polyphyllus, Diplodiscus verrucosus* and *Eugenia bracteata* were most abundant in plots without nurse-trees compared to with nurse-trees. Tree species of *Ixorapavetta, Cassine glauca, Glycosmis mauritiana, Pleurostylia opposite, Haldina cordifolia and Psydrax dicoccos* were most abundant in the nurse-tree plots.

Plant identification, plant specimens mounting on herbarium sheets is being done in the IFS lab. Data entering and analyzing is being carried out by using R and primer statistical software. Detail map of the Popham Arboretum is being prepared using GIS software.

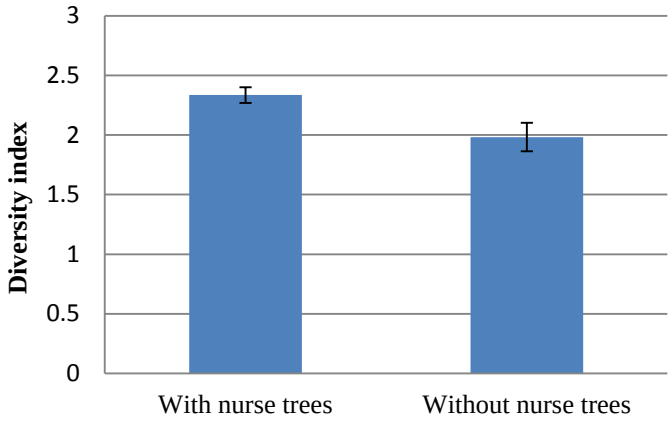


Figure 1.Means and standard error mean of tree species diversity indices. A two-sample t-test for independent samples showed that the mean diversity indices has significant different in restored area with and without nurse-trees in Popham arboretum, Dambulla (t=2.64, d.f.=9, P=0.028).

Mr. R. B. Hapukotuwa (Lab attendant) and Mr. A. B. Medawatte (Research assistant) taking DBH measurements of trees in Popham arboretum Dambulla.

Collaborators

1. Dr. M.W.S. Ranwala, Department of Plant Sciences. University of Colombo

Human Resource Development

M.Phil. students

1. Mr. G.D.A. Nalaka. (left in February, 2012).
2. Mr. A. B. Medawatte, Dept. of Plant Sciences, University of Colombo.

Undergraduate trainee

Ms. Ajani Rupasinghe, University of Rajarata, (January 2013 to July 2013)

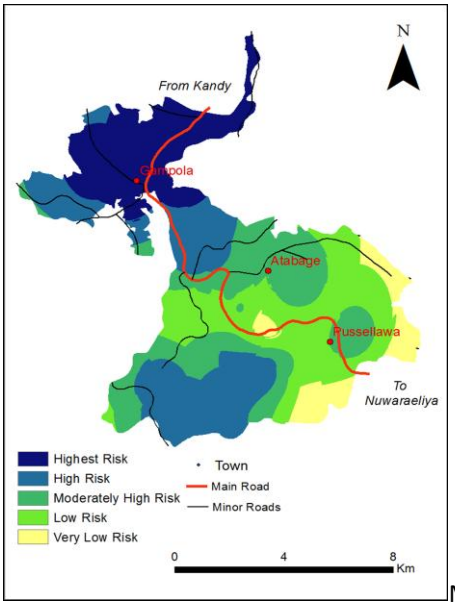
7.2.6.2.2 Preparing a dengue risk map for a sub-urban area in Sri Lanka

M.P. Madanayake[1], J. Gunatilake[2], S. Wijesundara [3], P.H.D. Kusumawathi[4] , M.C.M. Iqbal [1]

[1]Plant BiologyProject, Institute of Fundamental Studies, Kandy, [2]Postgraduate Institute of Science, University of Peradeniya, [3]Medical Officer of Health, Gampola, [4]Anti-Malaria Campaign,Watapuluwa

In this study we have focused on understanding a methodological framework to identify dengue risk geographically by using climate and socioeconomic parameters. To have a systematic approach in intervention programs, identification of threat areas due to dengue cases are important. The maps were geo-coded with addresses showing where the infected people live. This partially represents the transmission process only due to the geographic risk. Identified weather and socio-economic factors were mapped in a sub-urban area, Gampolaat the village level. With surveillance data for communicable diseases in place, public health professionals can use GIS to develop more effective programs to control the disease (Cromley and Mclafferty 2012). Dengue disease transmission can happen outside the residence.The data were obtained as physician confirmed dengue cases. All the raster maps were combined together and spatial models were prepared using Geographical Information System (GIS) to identify the risk areas. Geographically the risk areas were identified as urban to rural regions by the Dengue Risk Map (DRM).

A high percentage of concrete slabs and asbestos roofed houses were identified as dengue positive during the field visits. Concrete roof slabs were identified with a high number of mosquito breeding places during the rainy season. In houses with asbestos roofs the larvae were found in blocked rain gutters, which were inadequately cleaned. Thatched houses were identified as almost null in mosquito breeding. A spatial analysis of dengue in Thailand reported that the risk of DF was geographically homogenous and associated with housing types and poor garbage disposal (Thammapalo et al. 2008). Housing style was strongly related to the number of water jars and discarded items.



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with assigning weights

Sufficient open space in some dwelling types with many discarded items could be easily filled with rain water, which can create mosquito breeding sites. Humans are the reservoirs for the viruses and transportation leads to dengue spreading rapidly. Mapping

the education level was identified as the awareness of the people to the disease. When the supply of water is not constant, people tend to store water using all possible containers. In the study area houses which received water from mainline were found to store water in all possible containers. This leads to mosquito breed due to irregular cleaning of the containers. The supply of water from a source outside and adjacent to the premises involved storing of water

For a short period. Households which had water supply from the premises by a deep-bore well or an open well were identified as of less risk since they do not store water for long time. A similar study by

Bohra and Andrianasolo (2001) in India identified socio-economic factors in a community in Rajasthan as the major cause for vector breeding. Dengue is largely an urban disease and often found in urban communities with poorly managed water and solid-waste systems with poor vector control. In highly urbanized communities, high concentrations of people live in relatively small geographic spaces. As the density of people increases, the critical mass of transmissibility also goes up.

This study found that environment factors and socioeconomic factors are very important spreading dengue cases in the study area. In order to obtain a higher accuracy DRM it is recommended to obtain clinically diagnosed dengue incidences. Dengue disease transmission can happen outside the residence. An identified drawback of the data system was dengue confirmation was not done clinically and systematically during the study period.

Collaborators

1. Dr. J. Gunatilake, Postgraduate Institute of Science, University of Peradeniya
2. Dr. S. Wijesundara, Medical Officer of Health, Gampola
3. Dr. P.H.D. Kusumawathi, Anti-Malaria Campaign, Dutugamunu Mawatha, Watapuluwa
4.

Human Resource Development

M.Phil student: M. P. Madanayake, Postgraduate Institute of Sciences, University of Peradeniya

Undergraduate trainees

- H. Delvinne, Dept. of Zoology, University of Colombo.
- M.H. Navoda Mihiraj, Dept. of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna.

7.3 ENVIRONMENTAL AND EARTH SCIENCES

7.3.1 PRIMATE BIOLOGY AND BIODIVERSITY CONSERVATION

Project Leader: Dr.W. P.J. Dittus *(Visiting Senior Scientist)*

Description of the Project

This is an overview of our research program that has been ongoing for many years. The program involves observational studies of monkeys (primates) in their natural forest habitats, especially at Polonnaruwa. We aim to establish new knowledge concerning the biological foundations for social behaviour in primates (including humans). Behaviour touches many aspects of biology and therefore our aim has interdisciplinary ramifications. Past publications, for example, have addressed the interrelationships among social organization, genealogy, ecology, genetic diversity and environmental change. In particular we are interested in measuring the effects of such variables on the Darwinian fitness and demography. 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 physical growth. Such data are used to test current socio-biological and evolutionary hypotheses and have broad relevance in science and conservation.

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 completed the patrilineal identification of about 1,500 macaques. Our methods are similar to those of actuaries; linking variables of behaviour and environment to those of survival. To this end, we require large samples over extended periods of time to assure statistical soundness. Some years ago we have begun similar investigations of the gray and purple-faced langur at your research site at Polonnaruwa. New studies focus on the slender loris as well.

Our research has practical applications relevant to Sri Lanka's national development. For example, we have shown (in collaborations with veterinarians from the University of Peradeniya) 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. We have assisted local government in mitigating the conflict between humans and monkeys. We have contributed awareness of conservation issues by way of local media and school outreach nature education programs. Finally, our research has been broadcast globally through high quality documentary films in a bid to educate the public and win human sympathy and support for nature conservation. Our films have given Sri Lanka a positive image in the international political and economic arenas, and have drawn tourists to the country.

7.3.1.1 Arboreal adaptations of body fat in wild toque macaques (*Macaca sinica*) and the evolution of adiposity in primates

W. P. J. Dittus

Institute of Fundamental Studies, Kandy, and Smithsonian Conservation Biology Institute, USA

There is a paucity of information on body composition and fat patterning in wild nonhuman primates. Dissected adipose tissue from wild toque macaques (*Macaca sinica*) (WTM), feeding on a natural diet, accounted for 2.1 % of body weight. This was far less than fatness reported for nonhuman

primates raised in captivity or for contemporary humans. In WTM, fatness increased with age and diet richness, but did not differ by sex. In WTM (none of which were obese) intra-abdominal fat filled first, and "excess" fat was stored peripherally in a ratio of about 6:1. Intermuscular fat was minimal (0.1%). The superficial paunch held <15% of subcutaneous fat weight in contrast to its much larger proportions in obese humans and captive monkeys where most added fat accumulates subcutaneously. With increasing total adiposity, accumulating fat shifted in its distribution among 8 different main internal and peripheral deposit areas - consistent with maintaining body balance and a low center of gravity. The available data suggest that, in arboreal primates, adaptations for agile locomotion and terminal branch feeding set constraints on the quantity and distribution of fat. The absence of a higher percentage of body fat in females and neonates (as are typical of humans) suggests that arboreal adaptations preclude the development of fat-dependent, large-brained infants and the adipose-rich mothers needed to sustain them. The lifestyle and body composition of wild primates represent a more appropriate model for early human foragers than well-fed captive monkeys do.

7.3.1.2 A call to align the management of Sri Lanka's heritage sites with ancient cultural values and UNESCO policy

W.P.J. Dittus[1] and K.A.S. Gunathilake[2]

[1] *Institute of Fundamental Studies, Kandy,* [1]*Smithsonian Conservation Biology Institute, USA,*
[2]*Association for the Conservation of Primate Diversity, Sri Lanka*

The preservation of Sri Lankas ancient cultural heritage would benefit from a more balanced distribution of emphasis in management and conservation among the different elements that constitute this heritage. The elements of the ancient civilization includes not only (a) the physical remnants of monuments and artifacts, (b) the tanks and irrigation systems, but also (c) the living forest gardens, and the natural environment that buttressed the quality of ancient life. Currently, most archaeological attention and resources are focused on the reconstruction and preservation of ancient stone monuments, infrastructural modernization and tourist management. The ancient cultural heritage, however, extends far beyond monuments.

Forest gardens, for example, were an integral part of the ancient civilizations of South Asia. In Sri Lanka, historical evidence for their existence is widespread being associated with at least 27 sites, the most prominent are known from Sigiriya, Mihintale, Sithulpawa. Rithigala and Polonnaruwa. Their antiquity in Sri Lanka goes back to at least King Mutasiva's period (307-247 BC) (Mahavamsa: Geiger 1912), and their importance to spiritual life was indicated by king Devanampiyatissa (246-206 BC) who venerated the Buddha with a symbol of natural forest when he planted the Bodhi tree in his father's Maha mevna uyana. Forest gardens were prominent in secular life as well. For example, in the Chulavamsa it is written that King Parakrama Bahu (1153-1186 AD) built a garden of fruit (palaarama) at Lakssha uyana at Polonnaruwa. Other gardens emphasized the esthetic with flowers (pushpaarama) and physical comfort and relaxation with shade trees (punjarama). In his book "*A Selection of Indigenous Trees for Traditional Landscape in Sri Lanka*" Professor Nimal De Silva illustrates many of the tree and plant species that were important in antiquity and included many varieties of mango that currently are no longer available through modern neglect. Not only were forest gardens an integral part of daily spiritual and secular life, but the importance of the natural world in general was appreciated and extended far beyond managed forest gardens.

In step with Sri Lanka's Buddhist and Hindu religious traditions, the Mahavamsa chronicles reveal that the ancient kings of Sri Lanka were highly valued the natural world around them. As far back as at least 24 AD, King Amanda Gamini (19-29 AD) banned the killing of all animals. Others, like King Nissanka malla (1187-1196 AD), forbade the destruction of life on land, in the air, and in all waters of his extensive kingdom, and extended this protection to some native trees. Evidence for these royal

decrees are found carved in stone among the archaeological remnants of these kings' palaces and temples at Polonnaruwa, Mihintale and Anuradhapura. The king's' proclamations over many centuries were the equivalent to the establishment of the world's first official nature sanctuaries.

Given this ancient tradition, it is particularly poignant that, aside from rhetoric, Sri Lanka's natural heritage is losing ground to narrow interests. The ongoing neglect and even trashing of the natural aspects of Sri Lanka's heritage sites is at odds with ancient cultural precedents and UNESCO guideline qualifications.

Collaborators

1. Prof. R. P. V. Jayanthe Rajapakse, Professor of Parasitology and Head of the Department of Pathobiology, University of Peradeniya, Peradeniya.
2. Dr. Ashoka Dangolla, Faculty of Veterinary Medicine and Animal Health, University of Peradeniya.
3. Professor Peter Nuernberg, Cologne Center for Genomics CCG, University of Cologne, Germany

Human Resource Development

In contrast to earlier years, local outreach educational programs in the Polonnaruwa area were minimal in 2013 because our field staff resources were diverted for the production of documentary films in collaboration with Disney Productions and the BBC. These documentaries, with their entertaining and educational qualities reach a television audience in the millions of people globally with an imbedded subtle message of a need for the conservation of nature. Local school programs will be reinstated in 2014.

Figure 1. Primate infants, such as this toque macaque (*Macaca sinica*), are born with virtually no body fat, thereby lessening the weight burden for mothers who carry them through trees. But this weight restraint also limits infant brain development, sharply contrasting human infants, which are the fattest of all mammals at birth. Human infant and maternal fat stores are critical as fuel for rapid infant brain development. The evolution of hominids hinged on the abandonment of arboreal life and a shift towards weight friendly terrestrial habits (Dittus, W. P. J. (2013). Arboreal adaptations of body fat in wild toque macaques (*Macaca sinica*) and the evolution of adiposity in primates. *American Journal Physical Anthropology* 152:333-344. DOI: 10.1002/ajpa.22351 (Photoby Barney Wilczak).

7.3.2 CHEMICAL AND ENVIRONMENTAL SYSTEMS MODELING

Project Leader: Dr. Meththika Vithanage *(Research Fellow)*

The Chemical and Environmental Systems Modeling Research Group works on understanding chemical processes in solid solution interface, assess, characterize, monitor water and soil pollution, salt water intrusion and model the systems in order to find solutions for human benefit.

Natural dissolution of serpentine; Possible toxic element leaching to the environment

This project began in the latter part of the year 2009 and the aim of the research was to understand the mechanisms of natural dissolution of heavy metal species such as Cr, Ni and Mn from serpentine soil. The research project is partially funded by a grant from the International Foundation for Science, Sweden.

Monitoring landfill leachate and its treatment using nano zero valent iron (NZVI)

This study began in 2010 and is a long term on-going study. Characterization of landfill leachate and soils from Gohagoda and Gampola solid waste dumps is undertaken. Air stable NZVI was synthesized using different organic compounds to see their potential for landfill leachate treatment. The project is partly supported by the JICA. About 37 million JPY worth of equipment was received and installed successfully in 2013.

Biochar for environmental remediation

Preliminary research began in 2012 and is on-going. The project was awarded a grant from the Ministry of Technology and Research in 2013. The focus of this research is to investigate characteristics of different biochars produced by various waste resources in Sri Lanka for pesticide remediation. Prof. Dinesh Mohan (PI from India) of Jawaharlal Nehru University, India visited the IFS during 2013. Biochar Research Initiative in Sri Lanka was inaugurated with a talk given by Prof. Mohan.

Perchlorate mobilization of metals and organics; Implications for Martian regolith

This research began in 2013. Perchlorate, a powerful oxidant, is not readily absorbed in minerals or organic surfaces. Martian soils show a higher concentrations of perchlorate (0.4 – 1 % ClO_4^-) than Earth. From 1976, scientists have been trying unsuccessfully, to find organics from Mars surface. The aim of this study is to understand perchlorate interactions in soil as an environmental hazard on metal mobilization as well as its capability of destroying organics in Martian regolith on the basis of model soils.

7.3.2.1 Metal ion release from serpentine soils in Sri Lanka

Meththika Vithanage[1*], Anushka Upamali Rajapaksha[1], Christopher Oze[2], Nishanta Rajakaruna[3] and C.B. Dissanayake[1]

[1]Chemical and Environmental Systems Modeling Research Group, Institute of Fundamental Studies, Kandy, [2]Department of Geological Sciences, University of Canterbury, Private Bag 4800, Christchurch, New Zealand, [3]College of the Atlantic, 105 Eden Street, Bar Harbor, ME 04609, USA

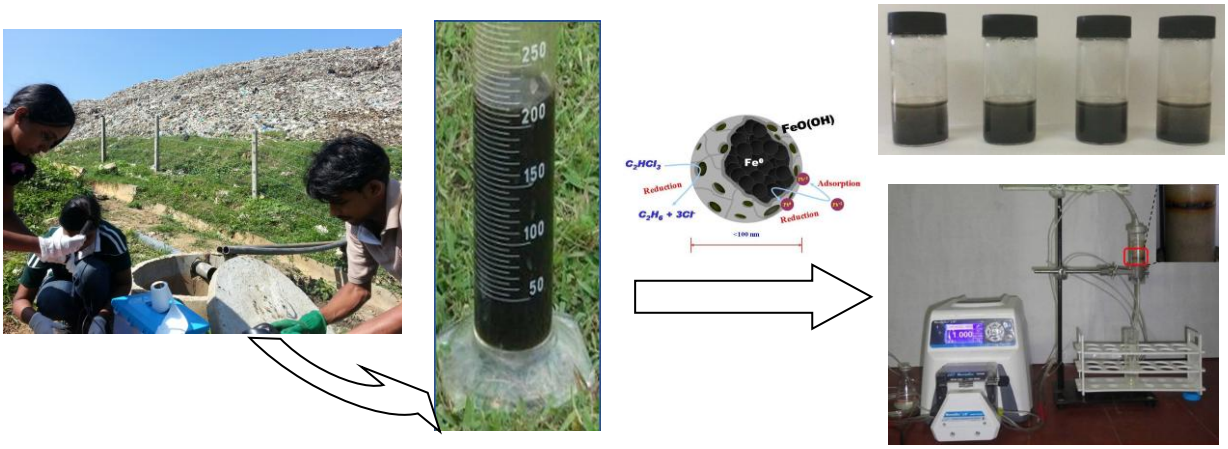
Ultramafic rocks and their related soils (i.e., serpentine soils) are non-anthropogenic sources of metal contamination. Elevated concentrations of metals released from these soils into the surrounding areas and groundwater have ecological, agricultural, and human health related consequences. Here we report the geochemistry of four different serpentine soil localities in Sri Lanka by coupling interpretations garnered from physicochemical properties and chemical extractions. Both Ni and Mn demonstrate higher release rates in water from the Ussangoda soils compared to the other three localities with Ni and Mn metal release increasing with increasing ionic strengths at all sites. Sequential extraction experiments, utilized to identify 'elemental pools', indicate that Mn is mainly associated with oxides/(oxy)hydroxides, whereas, Ni and Cr are bound in silicates and spinels. Nickel was the most bioavailable metal compared with Mn and Cr in all four soils, with the highest value observed in the Ussangoda soil at 168 ± 6.40 mg kg^{-1} via the 0.01M $CaCl_2$ extraction. Although Mn is dominantly bound in oxides/(oxy)hydroxides, Mn is widely dispersed with concentrations reaching as high as 391 mg kg^{-1} (Yudhaganawa) in the organic fraction and 49 mg kg^{-1} (Ussangoda) in the exchangeable fraction. Despite Cr primarily retained in the residual fraction, the second largest pool of Cr was in the organic matter fraction; 693 mg kg^{-1} in the Yudhaganawa soil. More critically, no significant levels of hexavalent Cr release were observed indicating natural attenuation, potentially related to the organic fraction. Overall, our results support that serpentine soils in Sri Lanka offer a highly labile source of metals to the critical zone.

7.3.2.2 Monitoring landfill leachate and its treatment using NZVI

S.S.R.M.D.H.R. Wijesekara[1*], B.F.A. Basnayake[2] and Meththika Vithanage[1]

[1]Chemical and Environmental Systems Modeling Research Group, Institute of Fundamental Studies, Kandy, [2]Department of Agricultural Engineering, University of Peradeniya

Gohagoda is an open waste dumping location at the world heritage city of Kandy in Sri Lanka. The leachate directly flows to the Mahaweli river which is the main water source for the entire province due to the absence of a proper lining system or any treatment mechanism before disposal. Hence, this study focused on characterization of leachate generated from Gohagoda dumpsite and treatment of the leachate using nano materials. Leachate samples were collected monthly throughout dry and rainy seasons from different points. The synthesized NZVI were characterized with advanced techniques. Comparison studies were carried out with four different nanomaterials to determine efficiency for treating landfill leachate. Series of batch, column and kinetic experiments were performed for actual leachate from Gohagoda and synthetic leachate for metal removal studies. Leachate characteristics confirmed its methanogenic nature and exceeds many allowable limits of Sri Lankan waste water discharge standards. Of the samples tested, starch-NZVI and mercaptoacetic-NZVI performed well for treatment of both COD and metal mixture. The removal percentages for COD, nitrate and phosphate from Starch-NZVI were 50, 97 and 99% respectively from batch experiments. Heavy metal removal was higher for S-NZVI (>95%) than other nano materials used. Hence, it can be proposed that the tested mercapto modified NZVI can be used as an integrated method for the landfill leachate treatment.



7.3.2.3 Development of biochars from tea residues and their application in carbofuran removal from water

S.S. Mayakaduwa[1], Dinesh Mohan[2], A. Karunaratne[3], Meththika Vithanage[1*]

[1]Chemical and Environmental Systems Modeling Research Group, Institute of Fundamental Studies, Kandy, [2]Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, [3]School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, India

Excessive use of pesticides has led to soil and water pollution. Carbofuran has been widely used in many countries including Sri Lanka. The objective of the present investigation was to develop biochar from disposable infused tea residue for carbofuran remediation from water. Locally collected infused tea waste was pyrolyzed at 300 and 700 ^{0}C. Developed biochars (TWBC300 and TWBC700) were characterized for pH, EC, CEC, moisture, mobile matter, resident matter and ash contents. Sorption experiments were conducted at different pHs and in 5-100 mg/L carbofuran concentration range using 1.5 g/L biochar dose. Ash content, pH, EC, and resident matter were higher in TWBC700 while CEC and mobile matter content decreased at 700 ^{0}C than in TWBC300. This increase may be due to the secondary decomposition and alkali residues formation at 700 ^{0}C. In the pH range of 3-5, carbofuran uptake had increased. The maximum adsorption was observed at pH 5 and then it started to decrease. Carbofuran removal was higher by TWBC700 than that of TWBC300. Adsorption capacity increased with rise in carbofuran concentration. Maximum adsorption capacity of 19 mg/g and 15 mg/g was achieved by TWBC700 and TWBC300, respectively. The infused tea residue biochars may be used for carbofuran remediation from contaminated water.

7.3.2.4 Perchlorate mobilization of nickel and organics in serpentine soils; Implications for Martian regolith

S. M. P. R. Kumarathilaka[1], Christopher Oze[2], S. P. Indraratne[3], Meththika Vithanage[1]*

[1]Chemical and Environmental Systems Modeling Research Group, Institute of Fundamental Studies, Kandy, [2]Department of Geological Science, University of Canterbury, Christchurch, New Zealand, [3]Department of Soil Science, Faculty of Agriculture, University of Peradeniya

The perchlorate concentration in the Martian soil regolith (0.4–1 % ClO_4^-) is significantly higher than on Earth. Perchlorate, a powerful oxidant, does not readily absorb in minerals or organic surfaces. From 1976, scientists were trying to find organics from Mars surface and several missions were placed with highly sophisticated instruments for analyzing soils from Mars with the objective of finding out whether or not organic compounds exist on the surface of the planet Mars. Yet nothing has been successful, and none of the missions found definitive evidence of Martian organic material. However, the ochloromethane and dichloromethane detected were suggested to have resulted from the combustion of perchlorate and soil organics. A more fundamental understanding is needed on the role of perchlorate and chlorate in such soils. Hence, the objective of this study is to obtain a fundamental understanding of perchlorate on metals and organics in Martian soil using a model soil, serpentine, which is quite frequently found on the surface of Mars. Kinetic experiment was conducted for the serpentine soils collected from Wasgamuwa and Ussangoda, Sri Lanka with the presence of different ClO_4^- concentrations, 1, 0.75 and 0.5 (w/v) respectively. Total Organic Carbon (TOC) and released Ni concentrations were measured at different time intervals until 11 days as a part of a long term study. The results showed a high Ni release for Wasgamuwa serpentine soil, 35.20, 31.06 and 28.18 mg kg^{-1} compared to Ussangoda soil, 16.90, 15.47 and 14.46 mg kg^{-1} with the presence of different ClO_4^- concentrations, 1, 0.75 and 0.5 (w/v), respectively. Removal of TOC was observed as 54.92 and 54.87 % for Wasgamuwa soil and 62.1 and 54.14 % for Ussangoda soil with the presence of different ClO_4^- concentrations, 1 and 0.5 (w/v), respectively. The findings of this study indicated that the ClO_4^- interactions in soil may lead to Ni mobilization as well as removing/destroying organics in the Martian regolith. Long term experiments are on-going.

Collaborators

1. Prof. Y.S. Ok (Director, Korea Biochar Research Center, Environmental Remediation and Restoration Laboratory, Kangwon National University, Korea)
2. Dr. Christopher Oze (Department of Geological Sciences, University of Canterbury, New Zealand)
3. Dr. Dinesh Mohan (School of Environmental Sciences, Jawaharlal Nehru University, Dew Delhi, India)
4. Prof. Nishanta Rajakaruna (College of Atlantic, Bar Harbor, ME, USA)
5. Prof. Ken Kawamoto (Graduate School of Science and Engineering, Saitama University, Japan)
6. Prof. B.F.A Basnayake, Dr. A. Karunaratne and Dr. M.I.M. Mowjood (Department of Agriculture Engineering, University of Peradeniya, Sri Lanka)
7. Dr. Herath Manthrithilake (International Water Management Institute, Sri Lanka)
8. Prof. S.P. Indraratne (Department of Soil Science, University of Peradeniya, Sri Lanka)
9. Prof. Gemunu Herath (Department of Civil Engineering, University of Peradeniya, Sri Lanka)

Collaborative research projects

1. Biochar for the remediation of antibiotics from soil and wastewaters: A research collaboration with the Kangwon National University, Korea (ongoing).

2. SATREPS (Science and Technology Research Partnership for Sustainable Development): UoP, Saitama University, UoR – JICA – JST grant for 5 years on Waste Dumping Sites in Sri Lanka (ongoing).

   Indo-Sri Lanka Bi-Lateral Research Project on tea residue biochar for pesticide remediation in water and soil for 3 years (ongoing).

Human Resources Development

Post graduate degrees obtained in 2013

1. Mr. S.S.R.M.D.H.R. Wijesekara – MPhil., PGIS, University of Peradeniya
Title of thesis:*Application of nano zero valent iron for the treatment of landfill leachate generated from Gohagoda municipal solid waste dumpsite*

2. Ms. D.M. Wijesundara - MSc , PGIS, University of Peradeniya
Title of thesis: *Soil and water contamination from Tannery waste: Fate, distribution and remediation of Chromium*

Research Assistants

1. Mr. S.S.R.M.D.H.R. Wijesekara (MPhil, 2013-PGIS, University of Peradeniya)
2. Mr. S.M.P.R. Kumarathilaka (MPhil Student, Pending Registration at PGIS, University of Peradeniya)
3. Mr. Indika Herath (MSc Student, PGIS, University of Peradeniya)
4. Ms. S.S. Mayakaduwa (Indo-Sri Lanka grant, MPhil Student, Pending Registration at PGIS, University of Peradeniya)

MSc Students

Ms. A Thilakarathna (PGIS, University of Peradeniya)
Ms. U Amanda (PGIS, University of Peradeniya)
Mr. Namal Wickramasinghe (PGIS, University of Peradeniya)
Ms. KHTDKumarasinghe (PGIS, University of Peradeniya)
Ms. DM Wijesundara (MSc, 2013-PGIS, University of Peradeniya)

Undergraduate Trainees

Mr. I.G.J.C. Harischandra (Department of Chemical Engineering, University of Peradeniya)

Ms. I.N.K. Darandakumbura (Faculty of Science, University of Peradeniya)

Volunteers

Mr. A.M.S. Wickremasinghe

7.3.3 ECOLOGY AND ENVIRONMENTAL BIOLOGY

Project Leader: Dr. S. P. Benjamin *(Senior Research Fellow)*

Description of the Project

The loss of quality habitats due to anthropogenic causes like over population, habitat degradation and climate change demands the urgent attention of biologists. The focus of our project is thus the study of the mega diverse fauna and flora of Sri Lanka. The primary focus however is the largely unchartered fields of invertebrate and small plant biodiversity. 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. The groups of our focus are still pseduoscorpions, spiders and orchid groups of high conservation necessity.

All research projects commenced in or around June 2009. The study of goblin spiders was initiated in 2012. One post doctoral scientist, one research assistant 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 (University of Rajarata, Sri Lanka; University of Peradeniya, Sri Lanka; University of Kelaniya, Sri Lanka; University of New Hampshire, USA; University of Arizona, USA; Zoologisches Forschungsmuseum Alexander Koenig, Germany).

Many projects focus on the collection and characterization of soil invertebrates with a worldwide focus. Currently we are undertaking fieldwork in various part of the island. Methodology includes traditional alpha taxonomic as well as molecular methods.



Post-doctoral Research Fellow:	Dr. Crisenthiya I. Clayton
Research Assistant;	Miss. Sasanka L. Ranasinghe
Senior Technical Officer:	Mr. Namal Atukorala
Volunteer Research Assistant:	Miss. Sachini Perera
Collection manager / Technical Officer:	Miss. Samanmadhu Weerakkody

7.3.3.1 Systematics, Biogeography and Evolution of Stephanopinae Crab Spiders (Araneae: Thomisidae)

S. P. Benjamin and C. I. Clayton

Ecology and Environmental Biology Project, Institute of Fundamental Studies, Kandy

Spiders (Araneae) are the second largest order after Acari, within Arachnida. Crab spiders (Family: Thomisidae) is a specious family which includes 2123 described species in 175 genera. Recent fieldwork, conducted around the globe (Sri Lanka, Madagascar and South America) by various institutions suggests that this is only a fraction of its true diversity. Crab spiders are mainly active during the day and ambush insects with their well-adapted first and second pairs of legs. Thomisids are behaviorally versatile, exhibiting complex behaviors, like their remarkable ability to change color, myrmecomorphism, and sociality. Understanding the phylogenetic structure of this large family has

always been problematic. Most published papers on higher-level thomisid relationships present poorly substantiated relationships. Their conclusions are based mostly upon inductive reasoning. Through this Project, we aim to provide a stable phylogenetic hypothesis for the family Thomisidae by analysis of morphological and DNA sequence data. This study will also form the basis of future revisionary work of the family, its biodiversity and conservation. To date we have images all type material of species of the genus Stephanopis from Australia. Preliminary data suggest that Australasian Stephanopinae may form a monophyletic radiation.

7.3.3.2 Diversity and distribution of Goblin spiders (Family: Oonopidae) in Sri Lanka

S.L. Ranasinghe and S.P. Benjamin

Ecology and Environmental Biology Project Institute of Fundamental Studies, Kandy

The spider family Oonopidae, commonly known as goblin spiders, includes over 600 described species in 88 genera. Members of this family are small (1-4mm), haplogyne, six eyed, free hunting spiders that dwell on litter or in the canopy. They do not build webs. Because of their size and cryptic habits, they have been grossly under sampled. Several Oonopidae taxa have been recorded in Sri Lanka. However, some genera have not been redescribed to date. Species of the genera *Aprusia, Brignolia, Camptoscaphiella, Gamasomorpha* and *Xestaspis*have been redescribed. However, species of *Epectris, Ischnothyreus* and *Orchestin*a were last reported almost a century ago. This study is aimed at studying the diversity of the family in Sri Lanka.

Sample collection was done in most provinces of Sri Lanka. Specimens were either collected by sifting litter or beating vegetation. Collected spiders were then sorted and preserved in alcohol and identified morphologically using recently published revisionary studies.

Our collection consists of over 20 specimens of the genera *Aprusia, Brignolia*and *Xestaspis.* The genus *Xestaspis*was recorded in the Kandy, Puttalam, Matale, Ampara, Nuwara Eliya, Kurunagala, Monaragala, Badulla and Anuradhapura districts. The genus *Brignolia* was found in the Puttalam, Kurunagala, Kegalle, Kandy, Matale, Ampara, Monaragala, Anuradhapura and Badulla districts. *Aprusia*is distributed throughout the Gampaha, Kandy, Rathnapura, Badulla and Anuradhapura districts. These three genera are more widely distributed in Sri Lanka compared to Eliya and Badulla districts, whereas the genus *Ischnothyreus*was only recorded in the Kurunagala and Kandy Districts. We also record a new genus for Sri Lanka, *Opopaea,*from the Kandy, Kegalle, Kurunagala, Matale, Badulla and Monaragala districts. Future work will focus on taxonomic revisions of Oonopid spiders of Sri Lanka based on morphology and molecules.

One specimen belonging to the genus *Camptoscaphiella*has been found in our samples from Kandy District. 15 specimens from the genus *Orchestin*a and six specimens from the genus *Ischnothyreus* have been identified. The genus *Orchestina*was collected in the Kandy, NuwaraEliya and Badulla districts, whereas the genus *Ischnothyreus*was only recorded in the Kurunagala and Kandy Districts. We also record a new genus for Sri Lanka, *Opopaea*, from the Kandy, Kegalle, Kurunagala, Matale, Badulla and Monaragala districts. Future works will focus on taxonomic revisions of Oonopid spiders of Sri Lanka based on morphology and molecules.

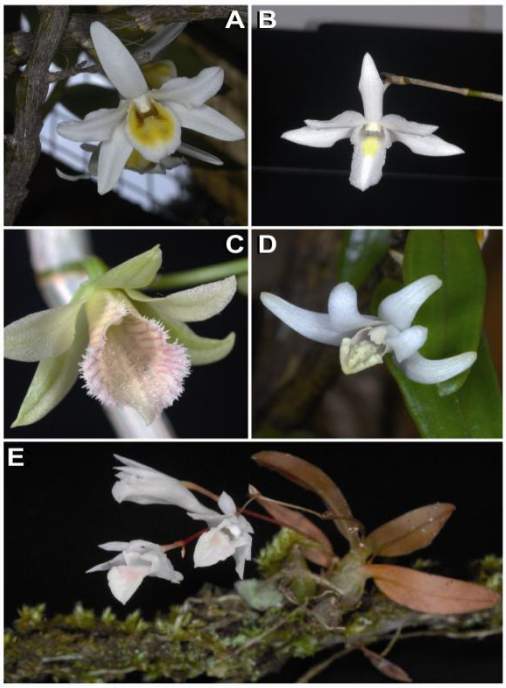
7.3.3.3 Taxonomic revision of the Genera Dendrobium and Bulbophyllum (Orchidaceae) of Sri Lanka

P.M.H. Sandamali[2], S.P. Senanayake[1], S.P.Benjamin[2]

[1] Department of Botany, Faculty of Science, University of Kelaniya, [2]Ecology and Environmental Biology Project, Institute of Fundamental Studies, Kandy

Orchidaceae is one of the largest plant families in Sri Lanka found in all terrestrial vegetation types. Seventeen field visits were undertaken to study the species of *Dendrobium*and*Bulbophylllum* this year. This year we were able to recorded *D.panduratum* and *D.macathiae*.Field work and data analysis of this project have now been completed. We were able to cover 47% of the photo documentation (62% of *Dendrobium* and 36% of *Bulbophyllum*). We have found six species of *Dendrobium* out of eight and seven *Bulbophyllum* out of eleven species reported for Sri Lanka. A further objective of this survey is to determine host plant specificity of our study species, which has now been completed.

Vegetative traits of all specimens were measured using a caliper and a measuring tape and dissected floral parts were drawn with the aid of a stereomicroscope equipped with a camera lucida. Vegetativeand floral morphometric data will be analyzed using the delta software package.



Photographs of *Dendrobium*spp. of Sri Lanka; A-*Dheterocapum*, B- *D crumenatum*, C-*D aphyllum*, D- *D nutans*, E- *D panduratum*

7.3.3.4 Biodiversity of soil scorpions and pseudoscorpions

S. P. Benjamin and C.I. Clayton

Ecology and Environmental Biology, Institute of Fundamental Studies, Kandy

Sri Lanka possesses a highly diverse endemic fauna and flora and is a reservoir of unique evolutionary history. Unfortunately, Sri Lanka's diverse invertebrate fauna remains largely unexplored. Several taxonomic studies on both vertebrates and invertebrates were published during British rule of the island. The standard work on Sri Lanka's invertebrate fauna was published as a part of the monographic series "Fauna of British India, including Ceylon and Burma", during this time. However, it did not treat many smaller arachnid orders like pseudoscorpions. Spiders were only partially covered, with the smaller species being overlooked. We are currently carrying out an island-wide survey of pseudoscorpions and spiders using a range of collection methods to sample a set of diverse habitats around the island.

Our survey of pseudoscorpions produced 51 species belonging to 23 genera of which eight species might be new to science. The family Cheiridiidae was discovered in the island for the first time. Out of the 51 species, 20 species (40 %) are endemic to Sri Lanka. A checklist of Pseudoscorpions of Sri Lanka submitted to the international peer-reviewed journal, ZOOTAXA is now in press. Two other publications are in review.

Photographs of living pseudoscorpions of Sri Lanka. A. *Stenatemnusbrincki*, female, Kitulgala. B. *Micratemnusanderssoni*, female, Sudagala (Kuruwita). C. *Oratemnusproximus*, female, Maradanmaduwa. D. *Oratemnus* cf. *indicus*, male, Wanathavillua. E. *Anatemnus* cf. *javanus*, male, Ohiya. F. *Anatemnusorites*, male, Alawala. G. *Indogarypusceylonicus* (Beier, 1973) new combination, female, Wanathavilluwa. H. *I. ceylonicus* (Beier, 1973) new combination, female, Padiyathalawa. I. *Indogarypusindicus*, female, Ohiya. J. *Feaellaindica*, female, Inginiyagala. All photos copy right Suresh P. Benjamin 2014.

Human Resource Development

U.G.S.L. Ranasinghe, IFS, Registered for M.Phil., PGIS, University of Peradeniya
Tentative title of the M.Phil thesis: *Revision of selected genera of goblin spiders (Oonopidae) in Sri Lanka*,

7.3.4 ENVIRONMENTAL ENGINEERING

Project Leaders: Dr. N.D. Subasinghe *(Senior Research Fellow)*
Dr. N. Nanayakkara *(Senior Lecturer, Faculty of Engineering, University of Peradeniya*

Description of the Project

Water pollution is a global environmental issue which occurs directly or indirectly when the pollutants are discharged into the water bodies without proper treatment. Industrial effluents are one such important pollutant route. Even in Sri Lanka it has made impacts on our economy, health and ecology. Phenolic compounds present in industrial effluents since those compounds are used in industries. Phenol and substituted phenol compounds in water have been recognized as major organic pollutants which have potential to act as human carcinogen. They pose considerable health concern, even at low concentration, due to their high toxicity, high oxygen demand and low bio degradability. Therefore, recently a great deal of attention has been created on contamination of water by phenolic compounds.

Several treatment technologies have been researched for recovery or destruction of phenol in water. Among the other technologies, electrochemical methods have gained more attention due to factors such as in-situ chemical generation, ease in process control and high efficiency. However, limited studies are found in literature for probing mechanism of degradation. In addition, little attention is paid towards the development and optimization of anode materials for specific contaminant. Therefore, this project addresses the above limitations by probing mechanisms of electrochemical degradation of phenol as a model system and by developing optimized anode materials. Subsequently the applicability of the technology in real phenol/phenolic wastewater samples will be tested.

The main aim of the research work is to develop an electrochemical method which is capable of treating phenol contaminated water and extending to real contaminated samples.

The specific objectives of the study are,

1. To provide insight into the mechanisms of anodic oxidization.
2. To develop and optimize the anode materials of the electrochemical reactor cell to oxidize phenol/ phenolic compounds in contaminated water.

In this study, both experimental and theoretical methods are used. Such investigations will provide insights to the process optimization. Dimensionally stable anodes will be developed and optimized in order to oxidize phenol/ phenolic compounds in water.

7.3.4.1 Anodic oxidation of Phenol in Contaminated Water on Dimensionally Stable Anode

H.A.P.P.B Jayathilaka[1], N.D Subasinghe[1], W.M.A.T.Bandara[2], K.G.N.Nanayakkara[1, 3]

[1] Institute of Fundamental Studies, Kandy, [2] Department of Chemistry, University of Peradeniya, [3] Department of Civil Engineering, University of Peradeniya

Introduction

Electrochemical oxidation is gaining more attention among organic waste water treatment techniques in recent years [1], because of factors such as in-situ chemical generation, ease in process control and high efficiency. In this case anode material has more influence on organic pollutant removal

efficiency [1]. Therefore, various anode materials have been subjected to study its efficiency. There is a health concern over phenol in water, as it has potential to act as human carcinogen, even at low concentrations, due to its high toxicity, high oxygen demand and low bio degradability. It is known as one of the major organic pollutants and many treatment techniques are tested on it. However, limited studies are reported in literature for probing mechanism of anodic oxidation and development of efficient anode materials for specific contaminant. Therefore, this project addresses the above limitations by developing optimized anode materials and probing mechanisms of electrochemical oxidation of phenol as a model system.

Objectives

Specific objectives of the work presented here are, to provide insight into the mechanisms of anodic oxidization and to develop and optimize the anode materials of the electrochemical reactor cell to oxidize phenol/ phenolic compounds in contaminated water.

Results

Theoretical and experimental results were obtained in order to confirm intermediates formation. Both studies confirmed the presence of catechol and benzoquinone. The reaction mechanism of anode was also revealed. In anode optimization stage, Ti substrate showed better results compared to stainless steel. The chemical oxygen demand (COD) removal (i.e.79%) and phenol removal efficiencies, hydroxyl radical generation capacities and electrochemically active area were improved while introducing a secondary metal oxide as a catalyst.

7.3.5 ESTIMATING OF SUB-SURFACE EXTENT OF EPPAWALA PHOSPHATE DEPOSIT

Project Leader: Dr. N.D. Subasinghe *(Senior Research Fellow)*

Description of the Project

Mineral exploration is one of the largest research fields in geophysics. Geoscientists around the world are working to estimate their mineral resources and developing new technologies to increase the efficiency of explorations.

Estimating the national mineral wealth is an integral part in planning the local economic aspects. However, no due attention is paid to the mineral resources of Sri Lanka, particularly the prospects in the subsurface. Most of the previous studies conducted by the Geological Survey and Mines Bureau to identify the mineral resources in Sri Lanka, were mostly based on client's requests instead of a national plan.

Eppawala phosphate deposit is one of the most important mineral ores in Sri Lanka. The Preliminary investigation was done by the Geological Survey Department in 1976. They mapped and estimated the ore using data from several boreholes and the survey was confined to a small area of the Eppawala quarry, which is now being mined. The subsurface extension of the deposit has not been adequately investigated ever since the first survey done in 1976. In fact, conventional exploration methods (i.e. borehole) are expensive and time consuming.

A new research project was initiated at IFS to develop a cheap, reliable and easier methodology based on geophysical techniques to estimate the extent of the Eppawala Phospahate deposit. National Science Foundation provided a grant for this research project, and the Geological Survey and Mines Bureau signed an MOU as collaborators.

Phosphate deposit at Eppawala has been formed as an in-situ secondary deposit. Parent material for the phosphate deposit came from the igneous rock, which is known as carbonatite. Magnetite is one of the common accessory minerals in the carbonatite, as well as its secondary product, the phosphate deposit. Due to this high magnetite content, phosphatic rock displays a specific magnetic signature that is useful in differentiating them from the surrounding non-phosphatic country rocks.

Since the phosphate minerals at Eppawala are essentially associated with magnetite, magnetometer surveys are considered as a reliable geophysical technique to investigate the sub surface extent of the apatite ore. Detailed magnetometer survey, with down line sampling rate and line spacing, will be conducted to determine the boundaries of the phosphate ore. In addition, 2D resistivity technique will be utilized to model the overburden thickness, when necessary. As the outcome of the study, the extension of the apatite body will be determined and the reserves of the remaining economic phosphate deposit will be estimated.

Identification of the total ore capacity helps to formulate new industries related to the raw mineral materials; in this case it is fertilizer. This study is helpful for the agro industries to plan their fertilizer

importing limits and to conduct research to increase the solubility of Eppawala phosphate such that short-term crops also get benefitted.

7.3.5.1 Magnetic anomalies and subsurface extent of the Eppawala phosphate deposit

W.K.D.G.D.R. Charles[1], S.M.N.D. Subasinghe[1], N. De silva[2], Pitawale[3], S.A. Samaranayake[4]

[1] Institute of Fundamental studies, Kandy.[2] Geological survey and mines bureau, Pitakotte.[3] Department of Geology, University of Peradeniya, Peradeniya,[4] Department of Physical Science, Rajarata University of Sri Lanka, Mihinthle.

Introduction

Phosphate deposit at Eppawala is one of the major economic mineral deposits in Sri Lanka. Despite its importance, no systematic survey has been done to estimate the extent of the deposit, since the first preliminary bore hole survey carried out over four decades ago. This research project will employ methodology based on modern geophysical techniques to estimate the sub-surface extent of the phosphate deposit.

Rocks with considerable amounts of magnetic minerals generate magnetic anomalies. Magnetite is present in Eppawala carbonatite host rock, as well as in the phosphatic rock in considerable amounts so that these rocks generate magnetic anomalies, which can be mapped using magnetometers.

Objective

Main objective of this project is to develop a geophysical methodology to differentiate the phosphatic ore from the surrounding country rocks and employ it to estimate subsurface extent of the Eppawla phosphate deposit.

Results

GSM-19 overhouse system with integrated GPS was used for the magnetic survey where the magnetic anomalies were plotted using a predefined grid. Magnetic anomaly and processed data are shown below.

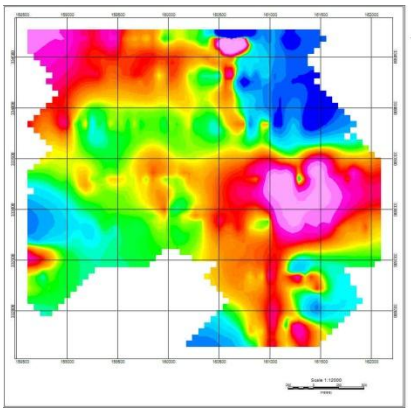


Figure 1. Magnetic anomalies map

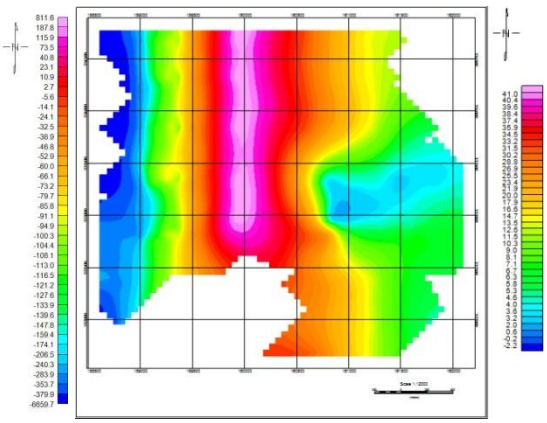


Figure 2. Processed data show the phosphate Deposit

7.3.6 RADON MAPPING PROGRAM IN SRI LANKA

Project Leader: Dr. N.D. Subasinghe *(Senior Research Fellow)*

Description of the Project

Radon is a decay product of radium, which in turn is a decay product of uranium. In the Earth's crust, uranium is generally concentrated in ore-bearing rocks scattered around the world. Although currently 36 isotopes of radon have been characterized, none of them is stable. Generally, "*radon*" refers to ^{222}Rn, which is the most stable radon isotope. Radioactive decay of most stable thorium isotope (^{232}Th) produces ^{220}Rn, which is generally called "*thoron*". On average, every 2.6 km^2 of surface soil, to a depth of 15 cm, contains approximately 1 gram of radium, which releases radon in small amounts to the atmosphere. Radon concentration varies wildly from place to place. In the open air, it ranges from 1 to 100 Bq/m^3.

In some countries, it is a requirement to monitor the radon levels and take mitigating actions if the levels are high enough to pose a health risk. Usually radon levels are varied seasonally throughout the year as well as within the day. Scientists monitor the seasonal variations of the indoor radon levels using passive radon detectors, which usually show accumulated counts during the exposure period. During last few decades several types of passive radon detectors were developed. One of the most common types is the CR39 based passive radon monitors that can discriminate between radon and thoron.

While indoor radon levels are important in assessing health risks, outdoor radiation levels are also important to monitor for many reasons. During recent years, some scientists have suggested that radon could be used as an indicator to predict the earthquakes as relatively larger quantities of radon may be released due to the opening of the faults prior to earthquakes. In addition, there is a possibility that radon concentration is higher at the faults and fractures in the earth's crust. High concentrations of radon can be also found in some spring waters and hot springs.

Because of radon's rapid loss to air and comparatively rapid decay, radon is used in hydrologic research studying the interaction between ground water and streams. Any significant concentration of radon in a stream is a good indicator that there are local inputs of ground water. Radon concentrations are generally higher over the faults. Similarly, it has found some limited use in prospecting for geothermal gradients. Measurement of environmental radioactivity is conducted around the country to establish the natural baseline for the country as well as to monitor any locations with unusual radiation levels. Some of the preliminary results are presented in this paper.

Radon-Thoron discriminative passive detectors with CR39 chips, provided by NIRS, Japan were used in this study for long-term outdoor monitoring. These detectors were installed at predetermined locations around the country. These locations were selected to represent a fair spatial distribution while considering the geological features such as faults and fractures. Further, detectors were established near the known thermal springs in the country. The passive radon detectors were placed in custom built housing to protect them from elements, as well as from possible damage by animals when installed outdoors. The location was accurately marked on a map using GPS reading. In-situ radiation measurements were also taken at the same locations for comparison.

Preliminary results indicate that thoron (^{220}Rn) levels are unusually higher compared to radon (^{222}Rn) levels in Sri Lanka. Same trend is confirmed by in-situ natural radiation measurements conducted by the Atomic Energy Authority of Sri Lanka earlier (Table 1.). Radon (^{222}Rn) is a product of radium decay, while ^{222}Rn (thoron) is a decay product of the most stable thorium isotope (^{232}Th). This is an indication that in average, Sri Lanka has a higher thorium concentration in its soil.

7.3.6.1 Measuring outdoor radon levels in Sri Lanka

N.D. Subasinghe[1], P.D. Mahakumara[2],T.B. Nimalsiri[1], N.B. Suriyaarchchi[1], T. Iimoto[3], T. Ishikawa[4], Y. Omori[4], C.B. Dissanayake[1]

[1]Institute of Fundamental Studies, Kandy, [2]Atomic Energy Authority, Wellampitiya, [3]The University of Tokyo, Hongo, Bunkyo-ku, 113-8654,Tokyo, Japan, [4]National Institute of Radiological Sciences, 263-8555, Chiba City, Japan

Introduction

For the first time in Sri Lanka, an outdoor radon mapping project was started. We installed passive radon detectors at selected locations and collected them after several months to measure the exposure levels. Active radon measurements are also being conducted by the Atomic Energy Authority.

Objectives

1. To carry out the first ever radon mapping program in Sri Lanka with a view to produce an outdoor radon distribution map
2. To understand the relationship between the radon levels and the geological features and mineral deposits

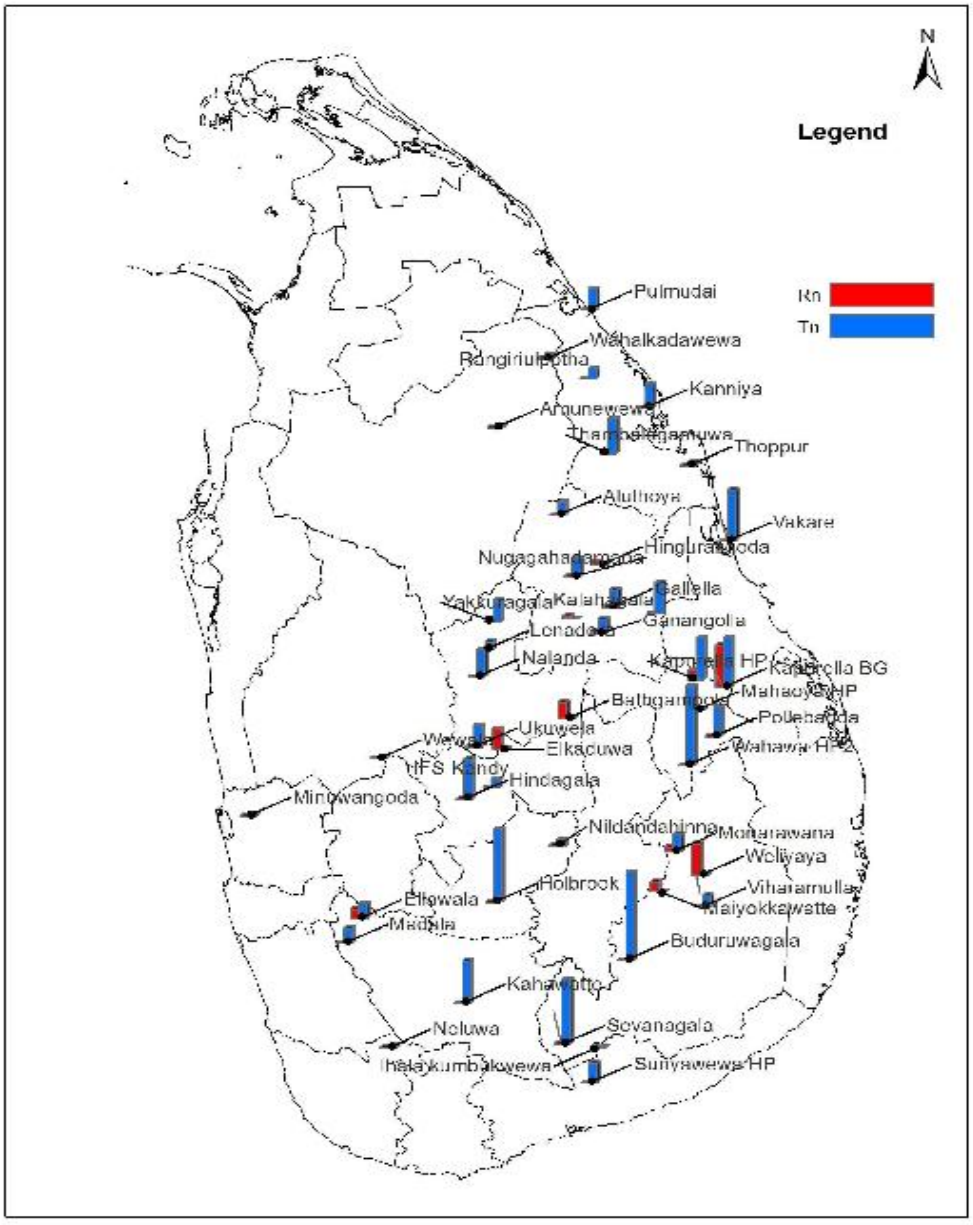
Results

It was found that the levels of ^{222}Rn, which is a decay product of ^{232}Th are very high in Sri Lanka compared to the levels in the region (Table 1).

Table 1. Naturally occurring radioactivity levels in some of the countries in the region. Note that highest value for ^{232}Th is from Sri Lanka, while ^{40}K and ^{226}Ra values are average.

Country	^{40}K		^{238}U		^{226}Ra		^{232}Th	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Bangladesh	350	130-610			34	21-43		
China	440	9-1800	33	2-690	32	2-440	41	1-360
Hongkong	530	80-1100	84	25-130	59	20-110	95	16-200
India	400	38-760	29	7-81	29	7-81	64	14-160
Japan	310	15-990	29	2-59	33	6-98	28	2-88
Kazakhstan	300	100-1200	37	12-120	35	12-120	60	10-220
Korea (Rep. of)	670	17-1500						
Malaysia	310	170-430	66	49-86	67	38-94	82	63-110
Thailand	230	7-712	114	3-370	48	11-78	51	7-120
Sri Lanka	**308**	**19-1378**			**49**	**5-761**	**138**	**9-1166**

Measuring background levels of radio activiity



Radon (Rn) and Thoron (Tn) levels of the study locations

7.3.7 WATER QUALITY IMPROVEMENTS IN THE DRY ZONE AREAS IN SRI LANKA

Project Leader: Mr. J.P. Padmasiri *(Visiting Research Fellow)*

Description of the Project

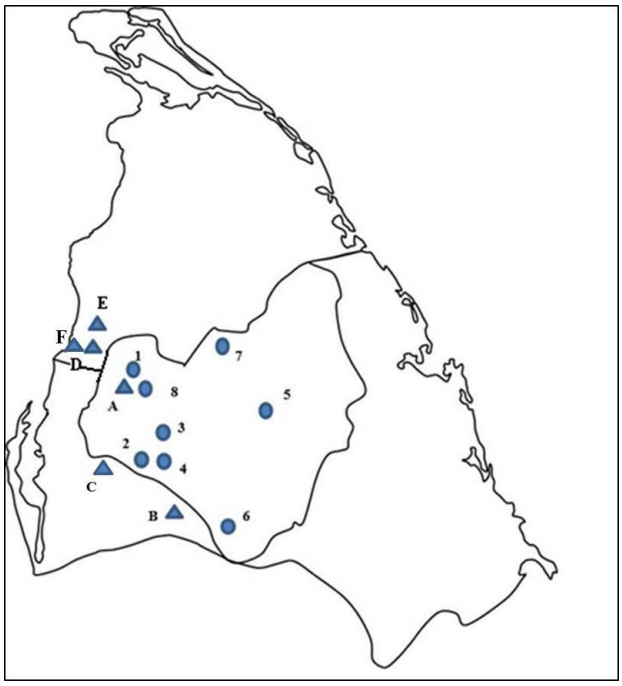
Adequate access to safe drinking water is a prerequisite in a healthy society. Presently it is a highly politicized issue and the cause for the prevalence of chronic renal failure is attributed to the lack of safe drinking water among the rural communities of Sri Lanka. In addition the rural community in Sri Lanka has to depend on ground water which has inherent quality problems such as excess hardness and fluoride in the drinking water. This project highlights the mitigative measures adopted in the challenging task of providing safe drinking water. The issues addressed so far include testing of wells and awareness programmes in schools and communities to identify good wells in the villages conducted by the Institute of Fundamental Studies (IFS). The microbiological quality of water can be improved by promoting boiled water for drinking. This aspect receives low priority in rural areas and thus school awareness programmes are absolutely necessary.

On the other hand 4500 community based water supply schemes were established for the supply of safe drinking water. Of these, 30% are not used by the people for drinking purposes due to the excess hardness and fluoride. This issue has been addressed by the IFS by introducing Electrocoagulation Water Purification Plants thereby reducing the fluoride content in water by 90% and the hardness content by 50%. Two such plants were established in 2011 in Asokamalagama, Mahavillachchiya (Anuradhapura) and Nikawewa, Moragollagama (Kurunegala). In 2012 eight such water purification plants were established in Anuradhapura district under the Deyata Kirula 2012 programme, funded by the Ministry of Technology & Research. Further, eight wells were installed in 2013 through Non-governmental organizations in the Vavuniya and Anuradhapura districts. The work was carried out in collaboration with Spectra Industries Lanka (Pvt) Ltd, Kurunegala.

Project Staff: Engineer W.M.Jayawardhane (Volunteer), Mr.Bandula Premathilke (Volunteer)

Benefits to the community:

- To provide safe drinking water to the rural community
- To reduce hardness and fluoride levels in drinking water
- Prevent tooth decay mainly by providing drinking water teeth with low levels of fluoride.
- Cost-saving and the least expensive way to deliver the benefits of fluoride to all residents of a community.
- Transferring technology to villages
- Empowering of women working as operators of the purification units
- Strengthening community based organizations



Funds from Private sectors

A - Asokamalagama, Nochchciyagama
B - Nikawewa, Kurunegala
C - 2 Acre farm, Cheddikulam
D - 400 Acre farm, Ulukkulama
E - 400 Acer Farm, Ulukkulam
F - Thattawa, Cheddikulam

Funds from Ministry of Technology & Research

1. Sisilasa Praja Moola, Mahavillachchiya
2. Suwapan Praja Moola, Nochchiyagama
3. Randiya Praja Moola, Nochchiyagama
4. Ekamuthu Praja Moola,Galadivulwewa
5. Mahasen Praja Moola, Mihinthale
6. Arunalu Praja Moola, Galnewa
7. Isuru Praja Moola,Medawachchiya.
8. Sahana Praja Moola, Pemaduwa

7.4 PHYSICAL AND COMPUTATIONAL SCIENCES

7.4.1 ARTIFICIAL INTELLIGENCE

Project Leader: **Prof. A. Nanayakkara** *(Research Professor)*

This project consists of two main research areas;

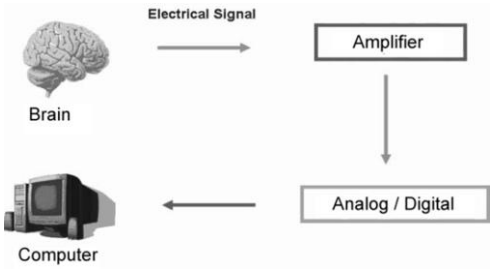
(a) Brain Computer Interface
(b) Sinhala Language Based Artificial Intelligence.

7.4.1.1 Brain Computer Interface

A Brain–Computer Interface (BCI) sometimes called a direct neural interface is a direct technological interface between a brain and a computer. It is a system that uses electric, magnetic or hemodynamic brain signals to control external devices such as switches, wheelchairs, computers or neuroprosthesis. 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).

The BCI project aims at building a high performance hardware and software system, which provides a communication link between the human brain and the 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. This way, patients who are with severe physical disabilities can control equipment such as wheel chairs, televisions, etc and communicate with the computer voice in his or her native language (Sinhala, Tamil or English).

Certain actions in a normal human brain can generate various responses such as metabolic activities or electromagnetic signals which can be detected by appropriate sensors and hence can be used for controlling BCI systems. As an example, brain activity can produce magnetic fields that can be detected using Magnetoencephalography (MEG). Certain brain activities may produce electrical signals that can be detectable on the scalp (EEG) or cortical surface or within the brain (ECoG). At present, EEG and ECoG are more popular as equipment needed for detection of other effects such as MEG is prohibitively expensive.



Although compared to MEG or functional Magnetic Resonance Imaging (fMRI) machines, EEG systems are much cheaper, still they are quite expensive for most of the people in Sri Lanka and hence they cannot afford to own EEG equipment. Therefore one of the aims of this project is to design and develop low cost software and hardware needed for BCI. Another aim is to develop a real-time BCI systemwhich 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.

7.4.1.2 Sinhala Language Based Artificial Intelligence

Individuals with speech disabilities (non-vocal) need an effective way of communication with the general public. In this project, we are developing a Sinhala speech synthesizer which can produce Sinhala speech, according to the input received from the disabled person. For disabled 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 (EMG) in any part of their bodies. Finally we hope to improve the system to a Portable Sinhala speech synthesizer using Microcontrollers (MCs).

7.4.1.1 Brain Computer Interface

Z. Sakkaff, D. Wijethunga and A. Nanayakkara

Artificial Intelligence Project, Institute of Fundamental Studies, Kandy

Introduction

BCI research group at the Institute of Fundamental Studies (IFS) is mainly interested inconstructing a BCI system based on EEG which can be used by the paralyzed people living in Sri Lanka. Since EEG equipment is usually expensive, 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 disabled 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;

Objectives

(1) Development of new methods and a software system to recognize thoughts from individuals and control external devices according to recognized thoughts. This includes finding new mental tasks which can be used with BCI systems more naturally and accurately.

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

Results (2013)

Due to lack of adequate funding as well as the delay in releasing funds, it was not possible to purchase a 128/64 channel EEG amplifier or 128/64 EEG electrode cap. As a result, planned investigations on source location, identification and optimal EEG electrode locations for Visual Arrow Movement (VAM) mental tasks could not be carried out. Only the software was developed for finding source locations using machine learning algorithms. Software based on Independent Component analysis was developed for blind source separation studies. The brain maps for six subjects corresponding to VAM mental task were produced using Common Spatial Patterns (CSP) with a 20-electrode EEG Amplifier in the AI laboratory. A paper based on these CSP brain maps was published in an IEEE international research conference.

7.4.1.2 Sinhala Language Based Artificial Intelligence

D. Wijethunga and A. Nanayakkara

Artificial Intelligence Project, Institute of Fundamental Studies, Kandy

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

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 disabled person. For disabled 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.

Results (2013)

Due to delays in receiving both capital and consumable allocations, all the required electronic components could not be purchased. As a result, construction of the complete speech system got delayed and will be completed in 2014 if requested funds are allocated.The prototype microcontroller based Portable STTS Synthesizer was modified to a real-time sound unit concatenation and producing synthesized Sinhala speech using PWM technique. Software for constructing Sinhala speech using reduced speechdatabase has been completed. An improved high resolution input screen with high quality Sinhala characters was constructed for character entry. A paper based on the work of speech generation was published in the Proceedings of the Sri Lankan Institute of Physics Technical Sessions.

Human Resource Development

Registered for M.Phil., PGIS, University of Peradeniya

1. Dammika Wijetunga, (Department of Electrical Engineering, University of Peradeniya)
   Title:*Design of a portable Sinhala speech synthesizer for persons with speech disabilities*

7.4.2 & 3 ENERGY FOCUSING PHENOMENA AND QUANTUM PHYSICS

Project leader: **Prof. A. Nanayakkara** *(Research Professor)*

This project covers two main areas of research;

(a) Computational and Experimental Investigations of Energy Focusing Phenomena (Single Bubble Sonoluminescence (SBSL))
(b) Quantum Physics

7.4.2.1. Single-Bubble Sonoluminescence

Single-Bubble Sonoluminescence (SBSL) is observed when a single gas bubble, which is acoustically levitated in a liquid, undergoes nonlinear oscillations in synchrony with the applied sound field and emits sub-nanosecond flashes of light at the point of maximum implosion. This is one of the examples of spontaneous energy focusing phenomena. As the bubble collapses, vibrational energy gets concentrated by at least a factor of $4x10^{11}$ to produce flashes of light in the UV range. These flashes of ultraviolet light have durations much shorter than a Nanosecond. At the latter stages of the collapse, both the temperature and the pressure inside the bubble reach extreme values such as 20,000K and 3,500 atm respectively. Also the bubble wall reaches acceleration over 10^{11}g near the maximum implosion. SBSL is observed by only with the bubbles having ambient radii between 1 μm to 10 μm and during the collapse, radii of these bubbles come down to 0.1 μm to 1μm.

The spectrum of SBSL is fairly broad, extending from above 700 nm to below 190 nm. The intensity of emitted light increases with decreasing wavelength up to the ultraviolet cutoff of water (about 200 nm, though anything below 250 nm is attenuated). In water, the spectrum of SBSL fits blackbody radiation with surface temperatures in the range 6000K–20 000 K for sound frequencies between 10 and 50 kHz. On the other hand spectrum of SBSL of an isolated bubble driven at 1 MHz sound frequency agrees well with thermal bremsstrahlung from a 10^6 K plasma [1].

There has been a large number of theoretical and experimental investigations carried out to explore, understand and predict the above mentioned exotic physical conditions which take place inside the SBSL bubbles at the time of light emission [2]. Most theoretical / computational models have been based on continuum fluid mechanics (e.g. Euler equations or Navier- Stokes equations) [2] and they were able to simulate some of the experimental results successfully. Since the majority of the models are based on fluid equations and during the last stages of the collapse, the speed of the bubble wall exceeds the speed of sound in water (or the liquid) and other extreme physical conditions can be observed inside the bubble, the validity of these models is questionable [3]. Further, all these fluid approaches are limited in their predictive power by the need to represent transport processes and the equation of state.

SBSLhas 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.

7.4.2.1.1 Computational investigation of Single Bubble Sonoluminescence

S. Karunawansha, M. Wijesingha, A. Nanayakkara

Single-Bubble Sonoluminescence Project, Institute of Fundamental Studies, Kandy

Introduction

Most theoretical / computational models of Single Bubble Sonoluminescence (SBSL) have been based on continuum fluid mechanics (e.g. Euler equations or Navier- Stokes equations) and they were able to simulate some of the experimental results successfully. Especially, the computational models developed by Yasui and others were able to simulate some sonochemical reactions correctly. Bubble collapse in SBSL can also be studied with Molecular dynamics (MD) and Monte Carlo methods. Two of the research groups; Puttermann's group at UCLA in USA and Kwak's group at Chung-Ang University in Seoul, Korea have developed software based on MD methods to simulate the bubbles with 50000000 particles. However, realistic bubbles usually contain 10^8 - 10^{10} particles.

Aims and objectives

The aim of this project is to understand the mechanism which produces light in SBSL. In order to find out what is going on inside the bubble when it emits light, we use computers to simulate the physical situation inside the bubble during the collapse. 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.

Results

The software based on the hydro-dynamical model developed in our laboratory for studying the collapse stage of the bubble was used for investigating the temperature and pressure dependence of SBSL in liquids with various physical properties. Effects of Alcohol on SBSL light intensity were investigated. MD based SBSL simulation software was developed and multithreading features were added to the code to improve the performance.

Detailedinvestigation of potential energy surface for NO & OH => NO_2 + H and NO + OH => NO + HO_2 were carried with sophisticated electronic structure methods. This investigation will help us to investigate reaction rates of more complicated sono chemical reactions taking place inside the SBSL bubble.A paper based on some of above work was published in Proceedings of the Sri Lankan Institute of Physics Technical Sessions.

7.4.2.1.2 Experimental investigation of single bubble sonoluminescence

P. Herath and A. Nanayakkara

Single-Bubble Sonoluminescence Project, Institute of Fundamental Studies, Kandy

Introduction

Single-bubble sonoluminescence (SBSL) spectra in H_2O show featureless continuum emission. Recently, it was observed that SBSL from H_2SO_4 is over 10^3 times brighter than SBSL from water and provides atomic, ionic, and molecular emission lines. In the year 2010, from an acoustically driven moving bubble in phosphoric acid (H_3PO_4), a very strong molecular emission was observed from excited OH radicals. The investigators were able to accurately estimate the temperature of the

bubble at the last stages of the bubble collapse. These new findings showed the complexity of SBSL and the importance of further experimental studies of SBSL in liquids other than water.

Aims and Objectives

In this project, we will find out experimentally whether the SBSL in acids such as Selenic (H_2SeO_4) and Selenious acids (H_2SeO_3) would produce spectral lines similar (or different) to what was observed in Sulfuric and Phosphoric acids. Further, we investigate how the intensity and spectral lines of SBSL in above two acids vary compared to Sulfuric and Phosphoric acids when physical parameters and the initial conditions of the bubble collapse change. As the first step, we will carry out detailed investigations on SBSL in Sulfuric and Phosphoric acids. This will help us to compare the results we acquire from Selenic and Selenious acids with Sulfuric and Phosphoric acids.

Results (2013)

Spectra of SBSL in various liquids were obtained with newly purchased UV-Vis spectrometer. To collect very low light intensities emitted by SBSL, it is required to have a new lens systems as well as very sensitive moving accessories. Due to delays in receiving funds for capital and consumable items in 2013, we were unable to purchase all the necessary items to do serious spectroscopic work on SBSL. As a result we were onlyable to do preliminary work on Sulfuric acid, effects of Fluorescein Sodium on the SBSL spectra at various temperatures, effects of nano powders on SBSL. Most of the necessary items have already been ordered. We expect to complete detailed investigations of the above mentioned effects after receiving them in 2014. A paper based on some of above work was published in Proceedings of the Sri Lankan Institute of Physics Technical Sessions.

7.4.3 Quantum Physics

T. Mathanaranjan and A. Nanayakkara

Quantum Physics Project, Institute of Fundamental Studies, Kandy

Introduction

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 the 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.

Aims and objectives

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.

Results

This project has produced 36 research papers in refereed journals and 3 research communications since its inception.

(1) A new powerful asymptotic energy expansion method was developed for 1-D systems. This method is based on the 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. In 2013, we have made good progress in extending Asymptotic Energy Expansion (AEE) method to various new systems which was developed by our laboratory.

(2) In 2013, four research papers on AEE method and Non-Hermitian systems have been published in Science Citation indexed journals.Based on research carried out in this project during last several years, we have received an invitation from Prof. Andreas Fring in the Centre for Mathematical Science at City University London, UK to do collaborative work with his research group and currently my research student Mr. Mathanaranjan is working (for six months) at the Centre for Mathematical Science at City University London, UK.

Human Resource Development

Registered for Ph.D./M.Phil., PGIS, University of Peradeniya

1. Mr. Thilagarajah Mathanaranjan - Ph.D.
   Title: *Extension of Asymptotic Energy Expansion method for Non-Hermitian systems*

2. Mr. Prabhath Herath – M.Phil.

   Title: *Behavior of Single Bubble Sonoluminescence in Acids*

3. Mr. Manoj Wijesingha – M.Phil.

   Title: *Determination reaction paths and barrier heights of sonochemical reactions using electronic structure methods.*

8. CONSULTATIVE AND COLLABORATIVE DIVISION (CCD)

Coordinator: Prof. S. A. Kulasooriya(*Visiting Research Professor*)

Co-coordinators: Prof. Gamini Seneviratne and Dr. Renuka Ratnayake

While considerable progress has been made in the projects continued from previous years, two new projects commenced during the period under review. This section will describe mainly the interactions between the CCD and the collaborating partners, while the research results are included in the respective units collaborating with them. Since the *Rhizobium* Inoculant Research & Production Facility and the *Spirulina* mass culture project operate directly under the CCD, those studies are described and their results are presented in this section.

Projects continuing from previous years

1. **Collaboration with Nature's Beauty Creations PLC (NBC) on Biofilm Biofertilizers** (BFBFs)
   IFS Scientists: Prof. GaminiSeneviratne and Prof. S. A. Kulasooriya.

   Collaborators: Mr. Samantha Kumarasinghe (CEO & MD) and Nishan Wickremasinghe

   (GM), Nature's Beauty Creations PLC, Kindelpitiya, Millewa, Horana

   The pilot project on the industrial production of BFBFs in 10L fermenters was successfully completed. In order to popularize the use of this product, 50ml test samples named "Biofilm-T" have been distributed free among a few selected tea growers. With the success of this testing, the production capacity has been scaled up to 1000L and a limited level sale of 250ml bottles of the product has commenced. The commercial scale production factory established at Hokandara started operations last month. These activities are temporarily conducted under the biofertilizer division of the NBC until a separate company is incorporated and registered.

   The initial agreement between the IFS and the NBC for the exclusive commercialization of BFBFs by NBC was amended and the amended version received the approval of the Governing Board of the IFS. The Board of the TRI has granted approval for the recommendation of this product for use in nursery tea. An agreement between the TRI and the IFS has also been signed for sharing of monetary benefits received from the sale of BFBFs.

Inauguration of the 1000L fermenter at the factory Biofilm-T" for marketing

Research results are presented under the Microbial Biotechnology Unit.

2. **Detection of Non-tuberculosis Mycobacteria (NTM) with microbiological and molecular typing methods**

IFS Scientist: Dr. D.N. Magana-Arachchi.

Collaborator: Dr. R.M.D. Madegedera, Physician, Respiratory Unit, Teaching Hospital, Kandy.

Project completed and the final report was submitted to the Tuberculosis campaign through Dr. Medagedera.

3. **Water quality and algal toxins in reservoirs and other sources of water used by the National Water Supply and Drainage Board (NWSDB) for water supply schemes**

IFS Scientists: Prof. S. A. Kulasooriya, Dr. D. N. Magana-Arachchi & Mr. J. P. Padmasiri.

Collaborators: Dr. S. K. Yatigammana, Department of Zoology, University of Peradeniya and Mr.S. K. Weragoda, NWSDB

The research student Ms. Buddhika Perera completed her experimental work on plankton studies of fresh water reservoirs of Sri Lanka and left the IFS. She is currently writing her M.Phil thesis. In her survey of 61 water bodies, she recorded a preponderance of cyanobacteria. Among them, toxigenic *Cylindrospermospsis* was predominant indicating a potential danger to one of our major water resources due to environmental pollution. A presentation on the distribution of *Cylindrospermopsis* in Sri Lanka was made by Ms. Perera at the 2nd International symposium on Water Quality & Health: Challenges Ahead, held at the PGIS, University of Peradeniya.

4. **Effective use of microbial bio-fertilizers for an improved economy and environment in Sri Lanka**

IFS Scientists: Prof. Gamini Seneviratne and Prof. S. A. Kulasooriya.

Collaborator: Prof. Ivan Kennedy, University of Sydney ABN 15 211 513 464, Sydney, NSW 2006, Australia

Under this project, island wide extension work was carried out in collaboration with the Department of Agriculture, Provincial Ministries of Agriculture, Plenty Foods Private Limited, NGOs and rural farmers to popularize the use of Rhizobia and BFBFs as low cost, environmentally benign fertilizers for sustainable crop production (Fig:1a).

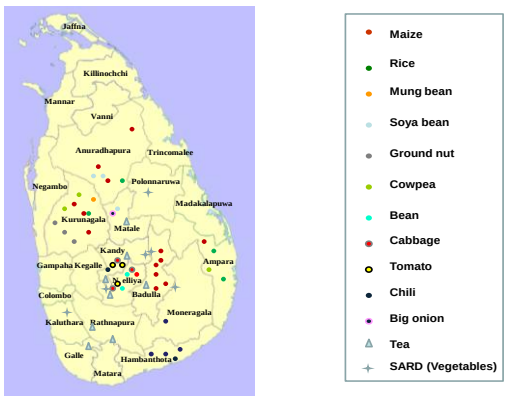


Fig 1a: Locations of Biofertilizer studies

Workshops and farmer-oriented field activities were also conducted to demonstrate the use of biofertilizer products prepared at the IFS (Fig 1b, c, d, e, & f). A number of field trials were conducted and some of them will continue next year.


With Plenty Food's farmers (1b) at Galenbindunuwewa and (1c) at Mahiyangana


(1d) Dept of Agriculture, Angunakolapelessa (1e) With vegetable farmers at Doragala


(1f) Demonstrating the use of inoculants (1g) With Wayamba Provincial Agriculture officers

1. Mass cultivation of *Spirulina* as a nutrient-rich food supplement against malnutrition

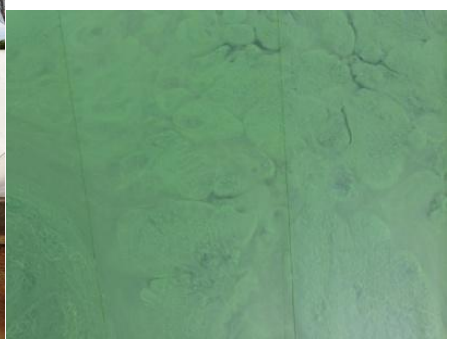
IFS Scientists: Prof. S. A. Kulasooriya, Dr. Dhammika Magana-Arachchi, Dr. Ruvini Liyanage and Dr. Viduranga Waisundara.

Collaborators: Major General (retired) W. J. T. K. Fernando and Mr. J. M. S. T. K. Jayalath, *Swayang Wattegedera*, Wattegedera, Murutenga

A research grant was awarded by the National Science Foundation in December 2012, for this joint project between *Swayang Wattegedera* and the IFS, under its Technology Grant Scheme. The IFS maintains pure cultures of the highly nutritive *Spirulina platensis* mother cultures and provide uncontaminated inoculants as and when required by the collaborator. The IFS successfully grew this alga in 20L aspirator bottles as well as small open tanks in the green house. Large scale outdoor culturing was then attempted at Wattegedera. After land clearance and leveling, 20 cement lined brick and mortar outdoor tanks (10m x 15m) were constructed by July 2013. After several changes of water in the tanks to consolidate and wash off possible toxic elements from cement, 5L of water from a tank was used to culture a sample of *Spirulina* to see whether the water was now suitable for algal culturing. Once successful growth was obtained each tank was inoculated with 6L of culture raised from the mother culture taken from the IFS. This operation commenced in mid-August and by November, eight outdoor tanks covered by a mosquito net-type material were in full cultivation. Large, transparent polystyrene roofs have been constructed over all the tanks to avoid disturbance by rain (Figs: 2a & b). While night and day temperatures of the tanks varied from 23^{o}C to 34^{o}C with a mean value of 30.4^{o}C, the pH variation ranged from 9.4 to 12.1 (very occasional) with a mean of 10.4. This high pH while stimulating the growth of *Spirulina* and producing luxuriant growth (Fig: 2c) has prevented the growth of contaminating algae. Periodic microscopic observations are made on small samples removed from the culture tanks to make sure that they remain uncontaminated. Averaging the results of harvests obtained from these 8 tanks during the month of November, 109 Kg of fresh *Spirulina* has been collected and this is equivalent to 10 Kg of dried *Spirulina* powder. On this basis, it is possible to obtain 25 Kg of dry *Spirulina* per month from 20 tanks. Our target is to increase this to 50 Kg.

2a: tanks covered with nets

2b: With the collaborator



2c: Surface view of thick Spirulina growth

Harvesting fresh *Spirulina* is tedious and time consuming, and attempts are being made to develop mechanical harvesting systems. The wet slurry harvested by filtering through a 10 micro mesh fabric is extruded through 'string hopper molds', allowed to air dry and then rapidly dried under the sun or in an artificial drier. These steps are still at infantile stages and the collaborator who is an engineer is planning to improve them through mechanization.

Harvesting fresh material Extrusion of harvest prior to drying

2. **Collaboration between the Alternative and Renewable Energy Unit of the IFS and the Mahidol University, Bangkok, Thailand.**
   IFS Scientist: Dr. Deepal Subasinghe

   Collaborator: Prof. Weerachai Siripunvaraporn, Program leader, Mahidol University.

   This project is continuing as planned.

7. Rhizobial Inoculant Research and Production Facility (RIRPF)

   IFS Scientist: Prof. S. A. Kulasooriya

   Research Staff: Mr. E.M.H.G.S. Ekanayake, Mr. R.K.G.K. Kumara, Mr. N. W.K. Wijesuriya & Ms. A.H.M.D. Abeyratne

   Mr. E.M.H.G.S. Ekanayake moved to the Microbial Biotechnology Unit from November 2012 and Mr. N.W.K. Wijesuriya (who was working in the project as a casual volunteer) was appointed as a temporary Research Assistant with effect from 1st October 2013.

   Due to the decision of the government to extend soybean cultivation in Sri Lanka, there was an increase in demand for inoculants during the Yala season of 2013. While the supply of inoculants during 2012 was for 3160 acres, the supply for 2013 increased to 8750 acres. Research studies conducted with inoculants for vegetable beans (*Phaseolus vulgaris*) at Hanguranketha, Rikillagaskade and Pussellawa have given very encouraging results (Figs. 3a, b & c) and we are confident of issuing inoculants for beans in 2014.

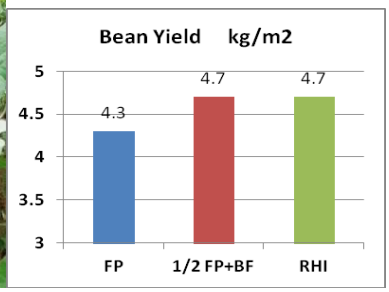


Fig 3a: Field trial on beans 3b: Bean harvest 3c Results (FP: Farmer practice, BF: Biofilm, RHI: Rhizobium)

8. Inoculants for Pasture Legumes

IFS Scientists: Prof. S. A. Kulasooriya, Mr. E. M. H. G. S. Ekanayake

Collaborator: Mr. Sarath Bandara, General Manager, Ambewela Farms

Having signed an agreement with Ambewela Farms PLC, experimental work commenced in 2013. The primary objective of these studies are to isolate suitable rhizobia from upland pasture legumes like clover, alfa-alfaetc, screen them for nodulation and nitrogen fixation and prepare inoculants that would enable the reduction of N-fertilize additions to pasture lands located among the pristine highland water shed areas of the major rivers of Sri Lanka.

Observations of the clover plants growing in pasture lands of the farm showed very little root nodulation perhaps due to the high levels of fertilizer-N added. Initial experiments done under laboratory and green house conditions at the IFS resulted in the successful nodulation of clover (Fig 4a). Rhizobia were isolated from these nodules, purified and screened. Inoculants prepared from promising isolates are being field tested at the farm in comparison with different levels of fertilizer-N additions (Fig 4b). A rhizobial broth culture was also sprayed to a newly harvested field growth of clover plants immediately after its harvest to examine its effect on re-growth in comparison with fertilizer-N applications (Fig 4c).

Fig 4a: Nodulation in Clover 2b: Laying field plots c: Spraying inoculants to Clover

New Project Agreements Signed in 2013

1. <u>Collaboration with Kurunegala Plantations Ltd., for the Development of Multi-Microbial Biofertilizers (MMBF) for Coconut</u>

   IFS Scientists: Prof. Gamini Seneviratne & Prof. S. A. Kulasooriya

Collaborator: Mr. N. M. S. K. Nillegoda, CEO and Mr. S. M. M. Samarakoon, DGM, Kurunegala Plantations Limited.

Agreement signed in March 2013. Having isolated soil and plant root associated microorganisms from plantations sites multi-microbial inoculants have been prepared. These are currently undergoing field testing with nursery coconut plants. Detailed results are presented under the MBU.

2. Collaboration with the South Eastern University of Sri Lanka (SEUSL) on Purification of Sri Lankan Natural Vein Graphite for Novel Technological Applications

IFS Scientist: Dr. H. W. A. C. Wijayasinghe

Collaborator: Dr. N. W. B. Balasooriya (SEUSL)

The agreement was signed on 23rd December 2013 and work started from 1st January 2014.

Human Resource Development

- Ms. K. M. D. Gunatilleke obtained an M.Phil degree at the PGIS, University of Peradeniya under the supervision of Dr. Renuka R. Ratnayake, co-supervised by Prof. Kulasooriya
- Ms. C. S. Hettiarachchi, co-supervised by Prof. S. A. Kulasooriya, is continuing her studies to complete a Ph.D degree in Rhizobioloy under a grant received from the National Research Council in which Prof. Kulasooriya is a co-investigator.
- Ms. Buddhika Perera supervised by Dr. Sudharma Yatigammana of the Department of Zoology, University of Peradeniya for her M.Phil Degree in Environmental Science is co-supervised by Prof. Kulasooriya.
- Mr. K. Mohanan supervised by Dr. Renuka Ratnayake of the IFS is co-supervised by Prof. Kulasooriya.
- Mr. N.W.K. Wijesuriya underwent training in soil microbiology and rhizobiology as a volunteer. He has been absorbed into the team as a temporary Research Asssistant.

09. AWARDS, RECOGNITION, PATENTS

1. **Prof. J. Bandara**
   - Awarded the Alexander von Humboldt Fellowship (3 months) 01/08/2013- 31/10/2013
   - Presidential Awards for Publications -2007, 2008 & 2009

2. **Prof. C.B. Dissanayake** – Presidential Awards for Scientific Publications 2007, 2008 & 2009

3. **Prof. M.A.K.L. Dissanayake**
   - Hon D.Sc. degree from Wayamba University of Sri Lanka in May 2013 in recognition of his long term services to develop science education and scientific research.
   - Session Chair, and Invited Speaker, Solar Asia International Research Conference, University of Malaya, KL, Malaysia, 2013.
   - Presidential Awards for Scientific Publications 2007, 2008 and 2009

4. **Dr. W.P. J. Dittus**
   - Presidential Awards for Scientific Publications 2003, 2004, 2006, 2007 and 2008
   - Listed in Wikipedia**:** http://en.wikipedia.org/wiki/Wolf_Dittus

5. **Prof. U.L.B. Jayasinghe** - Presidential Awards for Scientific Publications 2007 and 2008

6. **Prof. M.C.M. Iqbal** - Presidential Awards for Scientific Publications 2007 and 2008

7. **Prof. S.A. Kulasooriya**
   - July 2013: SUSRED AWARD by the National Science Foundation for supervision of an M.Phil student who completed the degree within the stipulated period.
   - September 2013: Degree of Doctor of Science (*Honoris causa*) at the General Convocation of the Sabaragamuwa University of Sri Lanka (SUSL).
   - October 2013: Sri Lanka Patent No: 15958 for the invention on Biofilmed Biofertilizers for the Improvement of Soil Fertility and Crop Production, shared with Prof. Gamini Seneviratne.
   - Presidential Awards for Scientific Publications 2007, 2008 and 2009

8. **Prof. N.S. Kumar** – Presidential Awards for Scientific Publications 2008 and 2009

9. **Dr. D.N. Magana-Arachchi**
   - A patent application was submitted to NIPO in Sri Lanka in 31st October 2013.
   - Presidential Awards for Scientific Publications 2008

10. **Dr. R.R. Ratnayake**
    - SUSRED Awards 2013: Support Scheme for Supervision of Research Degrees by National Science Foundation (NSF)
    - Presidential Awards for Scientific Publications 2007, 2008 & 2009

11. **Prof. Gamini Seneviratne** – Presidential Awards for Scientific Publications 2007 & 2008

12. **Dr. M.S. Vithanage**
    - SUSRED awards for 2012 from the National Science Foundation, Sri Lanka for the supervision of -MPhil degrees of Ms. R.M.A.U. Rajapaksha graduated from PGIS (2012).
    - SUSRED awards for 2011 from the National Science Foundation, Sri Lanka for the supervision of MPhil degrees of Ms. B.G.N Sewwandi graduated from PGIA (2011).
    - Patent filed: M.S Vithanage and S.S.R.M.D.H.R. Wijesekara. Synthesis of organic stabilized nano-particulate zero valent iron. LK/P/1/17302 Patents 21/08/2013 11:23 hdesk (Pending for the granting).
    - Presidential Awards for Scientific Publications 2007, 2008 & 2009

13. **Dr. A. Wijayasinghe** – Presidential Awards for Scientific Publications 2007, 2008 & 2009

14. **Mr. J. Akilavasan**
    - Commendation certificate for Prof. M.T.M Jiffry Memorial National award for Science popularization from the National Science Foundation, Sri Lanka-2013.

- INSA JRD-TATA Fellowship for research training at Indian Institute of Technology, Madras, 3 months (IITM) 2013 (to be taken)

10. DISSEMINATION OF SCIENCE

10.1 SCIENCE DISSEMINATION UNIT (SDU)

Objectives:

1. Foster the exchange of technical and scientific information for the scientific community
2. Promote the public understanding of science: *Mainly toimprove the enthusiasm and inquisitive minds of teachers, students and the general public about science.*

FORUMS FOR THE SCIENTIFIC COMMUNITY

A.1 Human Resource Development

M.Sc. in Science Education: H.M.R.P.K. Herath, Title of thesis: Effect use of simple models for learning chemistry in an enjoyable manner, PGIS, University of Peradeniya, 2013
Supervisor: Dr. C.T.K. Tilakaratne

A.2 Training Programme

Instrumentation Training Programme for Technical Staff
Rajarata University of Sri Lanka (25th Sep – 04th Oct, 2013

A 3 Special Lectures and Research Meetings

- **"Development of Microbial Functions"**
  Prof. Kohei ODA Associate Professor/Jawaharlal Nehru University
- **"Research findings on Plant Neurobiology"**
  Dr. P.S.B. Wanduragala, Secretary/IFS
- **"Functional Foods: A recipe for Health Living"**
  Prof. Sivali Ranawana, Former Director of National Livestock Development Board
- **"From farm to fork: The roles of Food Technology"**
  Dr. Anne Doloras Perera, Food & Nutrition Consultant (Fellow of the New Zealand Institute of Food Science & Technology)
- **"Use of common spatial patterns for improving the performance of classification of vam mental task"**
  Ms. S. Zahmeeth, Research Assistant, IFS

B. **Promotion of the Public Understanding of Science**

B.1 Workshops

07.02.2013	Science Workshop for grade 10 students in Yatawatta Weera Parakrama Madya Maha Vidyalaya, Matale - *120 students*
19.02.2013	Nano Technology Workshop in parallel with the Dayata Kirula 2013(in Ampara). Teachers and students actively participated in this workshop -*59 teachers and 259 students*
22.03.2013	Workshop for G.C.E. O/L students Walagamba Vidyalaya, Kegalle *(40 students*)

Science camps for all the students of grade 6 in the Kotmale Education Zone:

14.05.2013	Delta Gamunupura Vidiyalaya (200 students)

28.05.2013 Harangala Maha Vidiyalaya (200 students)

04.06.2013 Kubaloluwa Maha Vidiyalaya in Pundaluoya (200 students)

02– 03.08.2013 Science Workshop on Physics for plantation school teachers

40th School Science Programme
17 – 20 December, 2013

The school science programme (SSP) is the one of the most important annually conducted programmes for the dissemination of science among the younger generation. The aim of this activity is to expose young students to frontiers of science and give them an indication as to how science is actually practised. This programme enables students to meet and mix with students from different ethnic, economic and cultural backgrounds in an informal atmosphere which is an added advantage.

The SSP has been conducted as a continuous series from 1987 and a total of 2607 students have participated to date. This year we had a hundred and forty five students for the School Science Programme (SSP-2013) from all over the country. Those who excelled at the GCE O/L examination participated in this activity and this year we included an educational visit to the Ukuwela Power plant & the Dambulla Arboretum.

B.2 Laboratory Training and Lab Visits for Postgraduate Students, Undergraduate Students, Teachers and School Children

11.03.2013 Mowbray College, Kandy
G.C.E. A/L students of Mowbray College visited the IFS labs to inspire and motivate their minds.

30.04.2013 Rajarata University of Sri Lanka
Final year undergraduates from Rajarata University of Sri Lanka visited the IFS labs to improve their practical knowledge related to soil microbiology

30.05.2013 B.Sc Special Degree students (Physics) from University of Sri Jayawardhanepura visited the IFS.

11.06.2013 Muttur Central College
Twenty five G.C.E. A/L Science students and teachers of Muttur Central College visited the IFS labs to inspire and motivate their minds.

01.08. 2013 Matale Hindu College
G.C.E. A/L Science students of Hindu College visited the IFS labs to inspire and motivate their minds

02.08.2013 Uva-Wellassa University
3rd year undergraduates from Uva-Wellassa University visited the IFS labs to gain a practical exposure.

B.3 All Island Competition

Understanding the World through Science Competition – 2013

The Science Dissemination Unit organized a competition on the above subject among Sinhala and Tamil medium school students from grades 6 – 11. Science teachers were also motivated and inspired to be involved in this competition under a separate category. The objective of the project was to promote science concepts among teachers and students, and to enhance their inquiring mind towards science while making them inquisitive about science in the surrounding. We received about 5,000 entries for this competition.

The winners' celebration was held on 15th October 2013, under the patronage of the Honourable Minister of Technology, Research and Atomic Energy, Mr. Patali Champika Ranawaka at the auditorium of the Institute of Fundamental Studies.

Mr. L.G.D.P.M. Dissanayake was the best overall performer of the all island competition on 'Understanding World through Science 2013'. The gold medal was presented by the Honourable Minister Patali Champika Ranawaka on 15th October 2013 at the IFS.

B.4 Home Lab Tabloid

To enhance the science tempo of the school students, a tabloid was distributed among the school children with the "Vijaya Lama Newspaper".

130,000 tabloids were distributed free of charge with the "Vijaya Lama Newspaper" with funds from the Vidu Kirana project (a fund-raising project maintained by the Science Dissemination Unit).

B.5 Science YouTube Service

IFS official Channel
Publishing the videos of IFS special events such as lectures and workshops to build up an active audience online.

Vidu Nena Dasuna Channel
Producing videos about scientific matters related to O/L and A/L syllabuses. Subject matters were selected on the request of students and teachers.

B.6 Vidu Nena Hawula E-Project*:*

Free of Charge
To the best of our knowledge, this is the very first programme of this nature in South Asia which involves the following services:

- Science SMS
- Science e-mail
- Science twitter through mobile phones

We are sending Science SMS to registered participants every day except on government holidays. In addition, members receive one question and answer per week.

As the name "Vidu Nena Hawula" implies, it is an open forum for the subscribers to discuss their problems related to science behind day to day activities with the scientific community.

Miss. Tharushi Ranawaka was the Top Ranker of the Vidu Nena Hawula Service for year 2012/ 2013. The gold medal was presented by the Honourable Minister Patali Champika Ranawaka on 15th October 2013 at the IFS.

B.7 **Science Dissemination through Social Media**

a. Facebook

1. *Institute of Fundamental Studies Official Facebook Page*
   Informing the general public about public lectures and special lectures.
   Broadcasting important news of the IFS

2. *Vidu Nena Hawula Facebook Page*

b. Facebook Groups

Vidu Nena Hawula Facebook Group
Providing an area for students as well as the general public to discuss scientific matters and ask questions.

School Science Programme Facebook Group
For the SSP participants to keep contact with the IFS and among themselves.

c. Twitter

IFS Official Profile
Using a quick and efficient media base to deliver IFS news among subscribers.

Vidu Nena Hawula Profile
For the general public to subscribe and receive science news.

d. Blogger with Google+- *IFS Official Google+ Profile*
Vidu Nena Hawula Google+ Profile

10.2 DISSEMINATION OF SCIENCE BY RESEARCH GROUPS

a) Cell Biology Group

1. Awareness Exhibition on Kidney Diseases held at the Girandurukotte District Hospital, 5th- 7th September, 2013.

Consolidated Educational Exhibition on Renal Disease
District Hospital – Girandurukotte, 05 - 07th September, 2013

This exhibition was held to commemorate the 10th anniversary of Renal Clinic at District Hospital at Girandurukotte and to educate the students and the rural community about renal disease. The Cell Biology Group of the IFS participated in this exhibition and explained the possible toxic releasing ability in certain species of Cyanobacteria (blue-green algae) which is present in water and the effects of cyanotoxins on humans.

2. Lab evaluation, Six O/L & A/L laboratories in five schools of Kotmale Education District - 13th November 2013
3. School Science Programme 2013, held at the Institute of Fundamental Studies, Kandy, 17th – 20th December, 2013.

b) Physical and Computational Sciences
School Science Program 2013 - Lecture on Brain Computer Interface - held on 17-12-2013. Participants: 143 students.

c) Prof. S.A. Kulasooriya -. Lecture on Biodiversity and Bioresource Utilization at the 40th School Science Program, 17 – 20, December 2013. Participants: 143 students.

d) Prof. U.L.B. Jayasinghe - Chief Guest - Science Day, Maliyadeva College, Kurunegala, Delivered a lecture on "The Quality of Life through Chemistry" Oct. 15, 2013. Over 400 participants (students and teachers)

e) Prof. G. Seneviratne - Biofilmed Biofertilizers for Maize and Mung bean. Workshop conducted for Officers of Plenty Foods (Pvt.) Ltd. IFS. 11 July 2013.

f) Presentations by the Plant Biology Group

10/10/2013	Major Forest Ecosystems of Sri Lanka at Teldeniya National School (Organized by Forest Department Range Office Digana) – 100 participants
08/10/2013	Major Forest Ecosystems in the Knuckles range Galabodawatte Village Temple (Organized by Forest Department Range Office Digana) 100 participants
30/08/2013	Moraella Rain Forest Moraella Forest (Organized by Zonal Education Office Wattegama) 75 participants
20/09/2013	Major Forest Ecosystems in the Knuckles Range Knuckles Forest Reserve (Organized by Zonal Education Office Wattegama) 65 participants

g) Dr. N.D. Subasinghe conducted a public lecture on "Thermoelectricity for Co-generation and Energy Harvesting" at University of Kelaniya on an invitation from the Inst. Physics, Sri Lanka, on 11 Oct. 2013. Participants: 120

h) Mr. T. Nimalsiri, Mr, N.B. Suriyaarachchi and Mr. Sanath Opatha conducted demonstrations and lectures at the School Science Program.

i) Other events

Dr. Dittus - International Documentary Films:
We have used our scientific discoveries at Polonnaruwa to educate and inspire people world-wide towards nature conservation by way of documentary film productions broadcast on high profile television channels, in 2013 this was limited to: Disney Productions (USA): "Jungle Stories" (Jungle Bear Productions, UK).

11. LIBRARY

Our Mission

The Mission of the IFS library is to assist research staff and students to acquire the relevant literature for their research.

Services:

User services, technical services and reference services:

- Keep current records on resources, literature and selected publications in the library collection.
- Ordering and acquisition of books, journals and miscellaneous publications.
- Organization of the existing books and journals, document delivery, resource sharing, information alert services and sourcing web based electronic journals and articles.
- Collecting research articles and publications from IFS scientists.

Our Collection includes

Books & Periodicals	Government documents (gazettes, circulars)
Photographs	Architectural documents
Correspondence	Data on public work
Newspapers	Text and Ephemera
Directories	CDs Videos and electronic materials
Biographies	M.Phil and Ph.D theses
Maps, Posters	

Special Collections

Prof A. Kovoor's collection, Prof. Stuiver's collection, Mr. Lionel Liyanage's collection, Mr. V. Manoharan's collection, Professor Tissa R. Herat's collection, Prof. S. A. Kulasooriya's collections and the Sri Lanka Collection.

Present collection of the IFS library:

Collection	Added during 2013 January-December	Total as at 31st December 2013
Books	103	6427
Theses	2	105
CDs	12	380
Maps	56	535
Reports	18	523
Subscription to journals	12	>1000
Exchange journal	14	>1000
Reprints	15	728
Newspaper articles	26	112

The following multidisciplinary journals are available on line / print version:

Journals	Periods
01. Chemistry in Sri Lanka	1984-2013
02. Current Science	1999-2013
03. Economic Review Sri Lanka	2010-2013
04. JARQ-Japan Agricultural Research Quarterly	1998-2013
05. Journal of National Science Foundation of Sri Lanka	1973-2013
06. Journal of the Institute of Engineering, Sri Lanka	1994-2013
07. National Geographic	2008-2013
08. Nature	1962-2013
09. New Scientist	1982-2013
10. Resonance: Journal of the Science Education	2000-2013
11. Science	1955-2013
12. Scientific American	1951-2013

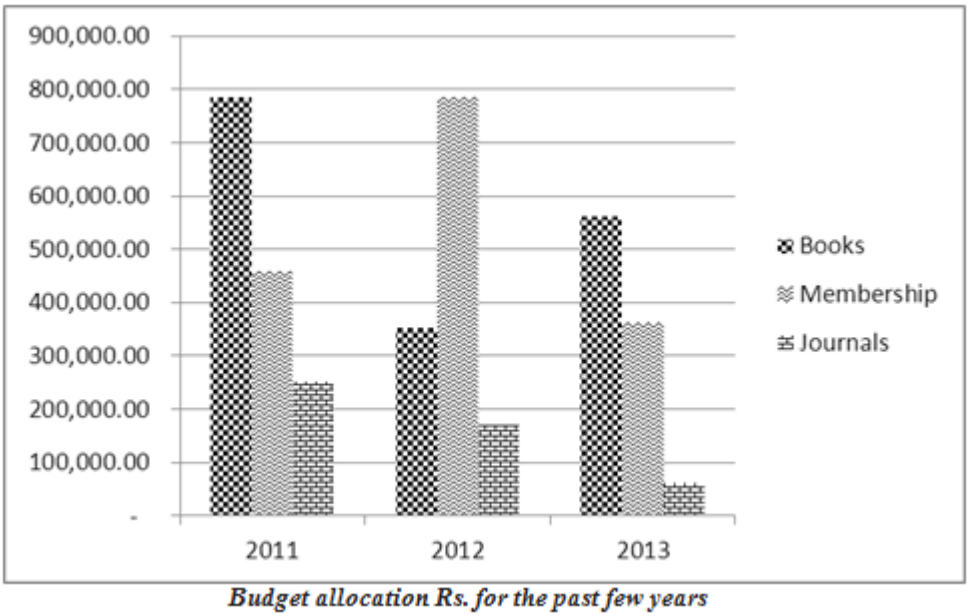
The Library also provides access to the OARE data base through subscription. OARE provides online access to one of the world's largest collections of environmental science research over 5710 peer-reviewed scientific journal titles and 1119 online books, owned and published by over 350 publishers as well provides online subscriptions to specialized journals to individual scientists. Currently 40 specialized journals are available online through this scheme.

Reader Services Statistics 2013

Total book circulation	720
Total journal circulation	195
Provided online journal articles	165
Number of visitors	10

Library Networks

Member of the SLSTINET and AGRINET



Budget allocation Rs. for the past few years

Conferences attended

- National Conference on Library and Information Science, (NACLIS) 2013. "New Technology, New Trends, New Ideas Modifying the Library with the User in Mind", 27th June 2013, Colombo, Sri Lanka.
- The Annual General Meeting of the SLISTINET at National Science Foundation on 6th March 2013.

Current Research

Information needs and information seeking behavior of Geoscientists in Sri Lanka.

Other Activities

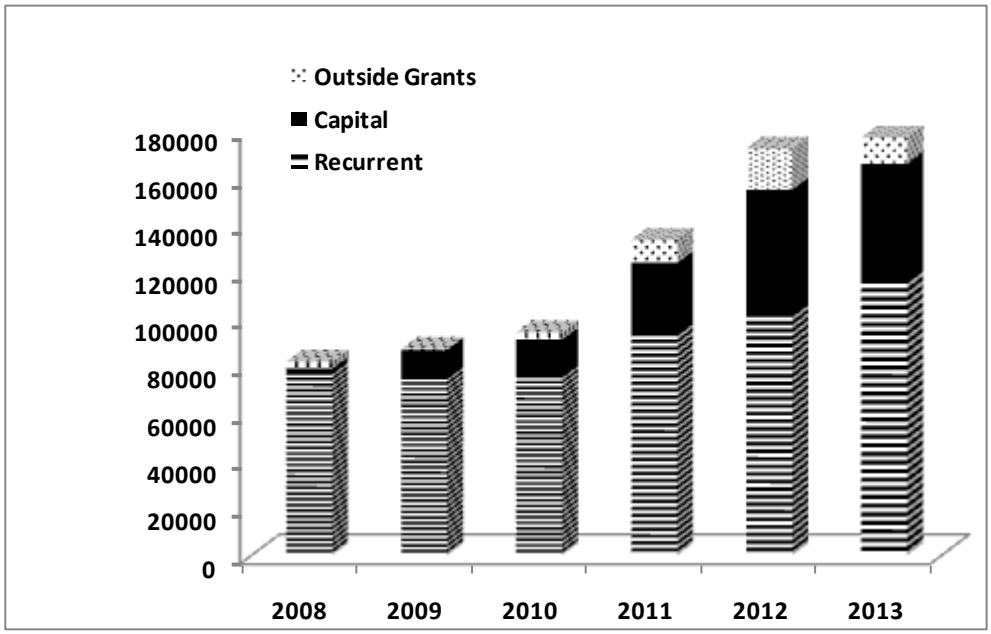
Made presentations on “Improving reading habits in children and introduction of Library System”:

- B/Dehigolla Maha Vidyalaya, Mahiyangana – 29/07/2013
- K/Waththegama Liyangaswagura Adarsha Kanishta Vidyalaya, Kandy – 30/10/2013

12. BUDGET

Total Annual Expenditure (Rs. '000)

	Item	2008	2009	2010	2011	2012	2013
	Personnel Emoluments	56,107	48,826	51,945	64,723	71,734	84,561
	Traveling Expenses	591	338	570	531	581	532
Recurrent	Supplies	5,355	7,822	6,763	7,484	8,952	10,018
	Maintenance Expenditure	4,165	6,035	5,063	5,454	3,796	2,891
	Contractual Services	11,618	6,043	9,817	12,488	13,540	14,258
	Other Expenses	237	6,992	2,509	4,042	4,306	5,185
		78,073	**76,056**	**76,667**	**94,722**	**102,909**	**117,445**
Capital	Capital Expenditure	1,344	11,216	15,123	29,731	52,644	49,210
		1,344	**11,216**	**15,123**	**29,731**	**52,644**	**49,210**
Outside Grants	Outside Grants	2,893	536	2,996	9,752	17,425	11,068
		82,310	**87,808**	**94,786**	**134,205**	**172,978**	**11,293**



Total Annual Expenditure for the past six years

13. IFS STAFF NEWS – 2013

13.1 RECRUITMENTS

The following staff were recruited to the IFS in 2013:

Dr. H.W.M.A.C. Wijayasinghe	-	Research Fellow
Dr. V.Y. Waisundara	-	Research Fellow
Mr. C.A. Thotawatthage	-	Research Assistant – Grade I
Dr. C.I. Clayton	-	Research Assistant – Grade 1
Mr. W.W.M.A.B. Medawatte	-	Research Assistant – Grade I
Ms. S.M.M.P.K. Seneviratne	-	Research Assistant – Grade II
Mr. S.M.P.R.Kumarathilake	-	Research Assistant – Grade II
Mr. K.M.S.D.B. Kulatunga	-	Research Assistant – Grade II
Ms. C.L. Kehelpannala	-	Research Assistant – Grade II
Mr. R.T.N. Rajapaksha	-	Research Assistant – Grade II
Mr. P.H.M.I.D.K. Herath	-	Research Assistant – Grade II
Ms. R.P.S.K. Rajapaksha	-	Research Assistant – Grade II
Ms. U.G.S.L. Ranasinghe	-	Research Assistant – Grade II
Ms. T.P. Keerthiratne	-	Research Assistant – Grade II
Ms. J.M.K.W. Kumari	-	Research Assistant – Grade II
Ms. C.O. Gunasena	-	Management Assistant – Grade III

13.2 INTERNATIONAL/NATIONAL COMMITTEES

Dr. Suresh P. Benjamin was elected as committee member of the Sri Lanka Association of the Alexander von Humboldt Fellows (SL-AvHF)

Prof. M.A.K.L. Dissanayake

- National Point of Contact (NPC) of Asian Physics Education Network (ASPEN, UNESCO) 2013.
- Member, Board of Management of the Institute of Fundamental Studies (2013)
- Member, Board of Management of the Postgraduate Institute of Science (PGIS), University of Peradeniya (2013)
- Member, Faculty Board of Science, University of Peradeniya (2013)
- Chairman, Panel on Basic Sciences, National Science Foundation (NSF), Sri Lanka (2013)
- Chairman/Member of the Committee on International Liaisons, National Science Foundation (NSF), Sri Lanka (2013)
- Reviewer for Journal of Power Sources (Elsevier), and Electrochemical Acta (Elsevier) (2013) and Journal of the National Science Foundation (JNSF), Sri Lanka (2013).
- Reviewer for several Research Grant Proposals from NSF, NRC and Universities

Dr. W.P.J. Dittus

- Editorial Board and Reviewer for Journal of Primatology
- Reviewer for National Science Foundation (Sri Lanka)

Dr. M.C.M. Iqbal

- Member of the General research Committee of the Sri Lanka Association for the Advancement of Science
- Council member of the Royal Asiatic Society of Sri Lanka
- Member of the Working Committee of the National Science Foundation

Prof. U.L.B. Jayasinghe,

- Member, Research Committee of the Faculty of Science, University of Peradeniya.
- Member, Governing Board of Institute of Fundamental Studies.
- Member, Editorial Board, *Ceylon Journal of Science*.

Prof. N.S. Kumar

- Member, Technical Advisory Committee on Good Laboratory Practices, Sri Lanka Accreditation Board
- Member, Board of Trustees, Peradeniya University Art Gallery & Museum Project, University of Peradeniya

Dr. R. Liyanage

Reviewer

- 24th Annual Congress of the PGIA 2013, University of Peradeniya
- Bioscience, Biotechnology, and Biochemistry
- British Journal of Nutrition
- Peradeniya University Research Sessions 2012

Dr. D.N. Magana-Arachchi

- Committee member; Board of Study in Biochemistry & Molecular Biology, Post Graduate Institute of Science (PGIS), University of Peradeniya, Sri Lanka
- Committee member; Sri Lankan Society for Microbiology (SSM)

Prof. G. Seneviratne is an Associate Editor, Agriculture, Ecosystems and Environment, which is an SCI journal, published by Elsevier.

Dr. C.T.K. Tilakaratne – Member of the NSF Working Committee on Science Popularization

Dr. Viduranga Waisundara

- Appointed by the International Union of Food Science and Technology (IUFoST) as the Global Harmonization Initiative (GHI) Ambassador for Sri Lanka from April 2013 onwards
- Appointed as a Council Member of the Sri Lanka Academy of Young Scientists (SLAYS) from December 2013 onwards

Reviewer

- American Journal of Chinese Medicine, World Scientific
- Food Chemistry, Elsevier
- Journal of Traditional and Complementary Medicine, Committee on Chinese Medicine and Pharmacy, Taiwan
- Life Sciences, Elsevier
- Third International Symposium of the South Eastern University of Sri Lanka, 6-7 July 2013

13.3 PARTICIPATION IN INTERNATIONAL/NATIONAL WORKSHOPS/TRAINING PROGRAMS/SEMINARS/CONFERENCES

Dr. Suresh P. Benjamin was invited to participate in the 1st national symposium on soil biodiversity, 10th 11th December 2013.

Mr. D.R. Charles attended - Geophysical Training conducted by Geol. Survey & Mines Bureau. Buttala, Eppawala and various locations & several occasions in 2013.

Prof. M.A.K.L. Dissanayake participated and presented a research paper on "*Active Learning Methods in Teaching Introductory Level Physics*" at the Asia Pacific Physics Conference (APPC-12), Tokyo, Japan (14-19 July 2013)

The following members of the IFS research group participated and presented research papers at the Solar Asia 2013 International Research Conference held at University of Malaya, Kuala Lumpur, Malaysia, 22-24 August 2013.

Prof. M.A.K.L. Dissanayake (Session Chair and Invited speaker)
Dr. G.K.R. Senadeera (Invited speaker)
Mr. C.A. Thotawatthage (presenter)
Ms. W.N.S. Rupasinghe (presenter)
Ms. H.N.M. Sarangika (presenter)
Ms.S.L. Jayaratne (presenter)

The following members of the IFS research group participated at the Solar PV workshop held at University of Ruhuna, Matara on 19-21 March 2013.

Prof. M.A.K.L. Dissanayake (Member, Organizing Committee)
Ms. K. Paramanathan (participant)
Mr. C.A. Thotawatthage (participant)

Mr. Dammika Wijetunga participated in the 29th Technical sessions of Institute of Physics, Sri Lanka (2013)

H. Delvinne, International Conference on Climate Change: Present concerns. 23-24 June 2013, Dept. of Geography, Andhra University, Vishakapatanam, India.

Dr. Dittus was an invited plenary speaker at the *Students Conference for Conservation Science*, hosted by the Indian Institute of Science at Bangalore, India, September 24-28, 2013.

Dr. Dittus and K.A.S. Gunathilake presented a paper at the International Conference on Asian Art, Culture and Heritage. August 221-23, 2013. Colombo. The paper was entitled "A call to align the management of Sri Lanka's heritage sites with ancient cultural values and UNESCO policy".

Dr. M.C.M. Iqbal

- Second International Symposium on Water Quality and Human Health: Challenges Ahead held at PGIS, Peradeniya from 15th to 16th, March 2013.
- Workshop on Green Chemistry held at Institute of Chemistry Ceylon, Rajagiriya on 04th January 2013.
- Second YSF symposium held at HARTI, Colombo on 18th January 2013.
- 69thAnnual Session of the Sri Lanka Association of the Advancement of Science held at University of Kelaniya from 2nd to 06th December, 2013.

U.L.B. Jayasinghe. Invited Lecture "*Search for Bioactive Compounds from Edible Fruits and Fungi associated with them".* Dec. 9-12, 2013. 14th Asian Symposium on Medicinal Plants, Spices and other Natural Products. Karachi, Pakistan

U.L.B. Jayasinghe. Invited Speaker, *"Edible fruits: Beyond Nutritional Value*" International Conference on Natural Products 2013, 4-6th March, 2013, Selangor, Malaysia.

Ms. B. Jayatilake attended the 4th International Conference on Structural Engineering and Construction Management, Kandy, Dec. 2013

Prof. S. A. Kulasooriya

- 2nd International symposium on Water Quality and Human Health: Challenges Ahead, 15 & 16, March 2013, PGIS, University of Peradeniya: Chaired a technical session and co-authored a presentation.
- Discussion of Collaborative Research Findings of Chronic Kidney Diseases of Uncertain Aetiology (CKDu), 26 Sept 2013, Committee Room A, BMICH, Colombo.
- National Symposium on Soil Biodiversity Conservation and Sustainable Use of Soil Biodiversity in Sri Lanka, 10 & 11, December 2013, held at the Sri Lanka Institute of Development Administration, Organized by the Biodiversity Secretariat, Ministry of Environment & Renewable Energy: Presented the Guest Lecture entitled *Soil Microbial Diversity and its use in Crop Production* and Chaired a Technical session.
- Technology Market Place organized by the Ministry of Technology & Research on December14 & 15, at the BMICH, Colombo. Participated in the meeting and discussion on the 15th and displayed a Poster and Rhizobial Inoculant packets in the IFS stall at the exhibition.

N.S. Kumar. Invited lecture on "*Catechins and Proanthocyanidins from Tea (Camellia sinensis: Antifungal Effects*." Dec. 9-12, 2013. 14th Asian Symposium on Medicinal Plants, Spices and other Natural Products. Karachi, Pakistan

R. Liyanage. Invited lecture on "Hypolipidemic and Hypocholestereomic Food Proteins and Pepties". Annual Sessions of the Nutrition Society of Sri Lanka, 2-3 February 2013, Taj Samudra, Colombo, Sri Lanka.

D.N. Magana-Arachchi

- MMDR-4, 4th International Symposium-cum-Training Course on Molecular Medicine and drug research', Dr. Panjwani Center for Molecular medicine and drug Research, International Center for Chemical and Biological Sciences, University of Karachi, Pakistan. 7th to 10th January 2013.
- Assessor Training Course for Good Laboratory Practice (GLP) – 28th-29th August 2013. Conducted by the Sri Lanka Accreditation Board for Conformity Assessment (SLAB).
- Assessor Training Course for Laboratory Accreditation ISO 17025 – 06th-10th May 2013. Conducted by the Sri Lanka Accreditation Board for Conformity Assessment (SLAB).
- Workshop on 'Patent drafting' – 28th - 01st February 2013. Organized by NSF, ITI and The Sri Lanka Alumini Association of the International Development Law Organization (IDLO) in collaboration with IDLO, Italy and the World Intellectual Property Organization (WIPO).

M.H.N. Mihiraj, International Symposium on Agriculture and Environment – Research to meet Global Challenges.March 15, 2013, University of Ruhuna, Sri Lanka.

Mr. T.B. Nimalsiri attended the Laboratory Training Course at ICTP, Italy. May-June, 2013.

N. Piyasena. Participant. Certificate Course on "*Introduction tot Gene Expression Studies*". July 11-12 2013, Agricultural Biotechnology Centre, University of Peradeniya

R.R. Ratnayake, participated in "Executive Technology Forum 2013: 23rd- 25th October 2013 in Bangalore

S. Sayanthooran

- Workshop on "Introduction to Gene Expression Studies", organized by Agricultural Biotechnology Center, Faculty of Agriculture, University of Peradeniya, Sri Lanka, on 11th and 12th July, 2013.
- Scientific and Engineering Symposium on "Environmental Pollution and Chronic Kidney Disease in NCP, Sri Lanka" held at Senate Room, University of Peradeniya, Sri Lanka, on 20th November, 2013.
- "National Workshop on Scientific Writing" organized by National Science Foundation and Postgraduate Institute of Science, University of Peradeniya, Sri Lanka, on 28th and 29th November, 2013.

G. Seneviratne – Participated in Agriculture, Ecosystems and Environment (AGEE) journal editors' meeting and First International Conference on Global Food Security (29 September 2013 to 02 October 2013- Elsevier science publishers, The Netherlands.

Dr. N.D. Subasinghe attended-:

- 3rd International Conference on Advanced Measurement and Test, Xiamen, China. 13-14 March 2013
- Training course in radon measurement & radiation protection, Bangkok, Thailand. 9-13 Sept. 2013

Dr. M. Vithanage and Mr. S.S.R.M.D.H.R. Wijesekara participated the International Conference on Solid Waste Management, Hong Kong, 5-10 May, 2013.

Dr. M. Vithanage conducted an invited lecture in the Special Session of Biochar; Waste to Wealth at the International Conference on Solid Waste Management, Hong Kong, 5-10 May, 2013.

Dr. Viduranga Waisundara

- New Zealand Institute of Food Science and Technology Annual conference as an invited speaker, session chair and judge of the student research symposium from 2-4 July 2013 in Hastings, New Zealand
- 13thASEAN Food Conference from 9-11 September 2013 at the Singapore Expo, Singapore
- Uva-Wellassa University Research Symposium from 12-13 December 2013 as a judge of the Animal Science Technical Session

Dr. A. Wijayasinghe

- 7th International Conference on Materials for Advanced Technologies (ICMAT, 2013), Singapore, 2013
- 30th Sessions of Geological Society of Sri Lanka, Kandy, 2013
- 69th Annual sessions of Sri Lanka Association for the Advancement of Science, 2013
- Annual Academic sessions of the Open University of Sri Lanka, 2013

- Annual research symposium of Uva-Wellassa University of Sri Lanka, 12-13 December 2013

Ms. Zahmeeth Sakkaff participated in IEEE International Conference ICIIS (2013).

13.4 ORGANIZATION OF SYMPOSIA/CONFERENCE/WORKSHOPS/TRAINING PROGRAMMES

Prof. M.A.K.L. Dissanayake: Member, International Advisory Committee, Solar Asia 2013 International Research Conference, University of Malaya, KL, Malaysia 22-24 August 2013.Number of Participants: 100.

Prof. M.A.K.L. Dissanayake, Member Organizing Committee, Solar PV Workshop, University of Ruhuna, Matara, 19-21 March 2013. Number of Participants: 70

Dr. D.N. Magana-Arachchi - Organizing committee member –2nd Annual Conference and Scientific Sessions of Sri Lankan Society for Microbiology (SSM) - 2013- 25th October 2013.

Prof. V. Thevanesam, Prof. N.S. Kumar, Prof. U.L.B. Jayasinghe and Prof. B.M.R. Bandara, organized the "*Workshop on Extraction, Screening and Bioassays for the analysis of Microbial and Plant Products*". Faculty of Medicine, University of Peradeniya & Institute of Fundamental Studies. Dec. 4-6 2013. (18 participants).
Dr. M. Vithanage co-organized the Biochar and Environmental Sustainability Workshop together with Prof. Yoshiyuki Shinogi, Department of Agro-environmental Sciences, Faculty of Agriculture, Kyushu University, Japan at the International Conference on Solid Waste Management, Hong Kong, 5-10 May, 2013. 22 participants from 10 countries.

Mr. Sanath Opatha participated in conducting technical training to technical officers from universities.

13.5 VISITS BY IFS SCIENTISTS

Dr. Viduranga Waisundara - The School of Chemical Sciences, University of Auckland, Auckland, New Zealand

13.6 RESEARCH GRANTS RECEIVED DURING 2013

Prof. M.A.K.L. Dissanayake and Dr. G.K.R. Senadeera

National Science Foundation, Sri Lanka; Title: "*Optimization of the growth process of cadmium sulfide (CdS) semiconductor thin films for efficiency enhancement in CdS/CdTe solar cells".* (2012-2014)

Prof. C.B. Dissanayake and Prof. M.A.K.L Dissanayake

National Research Council, Sri Lanka; Title: "*Synthesis, characterization and study of physico-chemical properties of some polymeric materials in the form of nanofibres and their applications in antimicrobial polymer nanofibre water filters and dye-sensitized solar cells"* (2011-2014)

Dr. M. Vithanage

Indo-Sri Lanka Bilateral Research Grant on "*Biochar for environmental management*" funded by Department of Science and Technology, India and Ministry of Technology and Research in Sri Lanka. (2013-2015)

Dr. D.N. Magana-Arachchi

NRC 11-059 – *"Gene expression analysis: Identifying the missing link in chronic kidney disease of unknown aetiology (CKDu) in Sri Lanka".*

Dr. A. Wijaysinghe

Co-investigator, received an Inovative Research Grant-2013 (Rs. 3,695,000) from the Ministry of Higher Education of Sri Lanka

Dr. M.C.M. Iqbal
National Research Council

- "Development of natural adsorbents for heavy metal and textile dye contaminated wastewater treatment" (PI)
- "Floristics, heavy metal tolerance and phytomining potential of serpentine flora in Sri Lanka" (Co-investigator)

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

NSF - (RG/2012/BS/06) "*Bioactive molecules from endophytic microorganisms associated with medicinal and allelopathic plants from Sri Lanka*" Rs. 1,148,200.00

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

NSF - (RG/2012/AG/01) "*Chemistry and Bioactivity of some popular edible fruits: Studies on possible application in health and agriculture*" - Rs. 1,870,964.

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

NRC (Grant No. 12-032) *"Bioactive metabolites from some selected Sri Lankan fruits and their associated fungi: possible uses in agricultural, pharmaceutical and functional food products*" - Rs. 5,425,000.

Prof. N. S. Kumar (Co- Investigator), Prof. V. Thevanesam (PI), Prof. B.M.R. Bandara (PI)

NRC Grant No 11-122 *"Characterization of the antibacterial activity of Triphala, a commonly used ayurvedic product, against multiresistant human pathogens"* - Rs. 4,818,430/40

Prof. U.L.B. Jayasinghe (Co –investigator), Dr. Kumudu Perera (PI)

NSF – (RG/2012/BS/01): *Identification and isolation of potential antidiabetic compounds from Sri Lankan Medicinal Plants*" - Rs. 1,306,000

Dr. N.D. Subasinghe

- National Science Foundation Grant No: RG/2012/NRB/03 Continued. Rs. 2,060,063
- National Inst. Radiological Sc., Japan, donated 2nd batch of passive radon detectors (50 detectors) for the Radon Monitoring programme.
- International Atomic Energy Authority, Austria provided training and 50 track detectors for indoor radon measurements.

14. RESEARCH PUBLICATIONS OF IFS MEMBERS – 2013

1. Akilavasan, J.; Wijeratne, K.; Moutinho, H.; Al-Jassim, M.; Alamoud, A.R.M.; Rajapakse R.M.G.; **Bandara, J.** Hydrothermally synthesized titania nanotubes as a promising electron transport medium in dye sensitized solar cells exhibiting a record efficiency of 7.6% for 1-D based devices. *J. Mater. Chem. A***, 2013,** 1, 5377-5385.

2. Akilavasan, J.; Wijeratne K.,; Gannoruwa, A.; Alamoud, A.R.M.; **Bandara, J**. Significance of $TiCl_4$ post-treatment on the performance of hydrothermally synthesized Titania Nanotubes Based Dye Sensitized Solar Cells, *Applied Nanoscience*, **2013.**

3. Arof, A.K.; Aziz, M.F.; Noor, M.M.; Careem, M.A.; Bandara, L.R.A.K.; Thotawatthage, C.A.; Rupasinghe, W.N.S.; **Dissanayake, M.A.K.L**. Efficiency enhancement by mixed cation effect in dye-sensitized solar cells with a PVdF based gel polymer electrolyte. *International Journal of Hydrogen Energy*, **2014,** 39, 2929-2935.

4. Bandara, T.M.W.J.; Jayasundara, W.J.M.J.S.R.; **Dissanayake, M.A.K.L**.; Furlani, M; .Albinsson, I; Mellander, B.-E. Effect of cation size on the performance of dye sensitized nanocrystalline TiO_2 solar cells based on quasi-solid state PAN electrolytes containing quaternary ammonium iodides. *Electrochimica Acta*, 109, **2013**, 609– 616.

5. Bandara, T.M.W.J.; Svensson, T.; **Dissanayake, M.A.K.L**.; Furlani, M.; Jayasundara, W.J.M.J.S.R.; Fernando, P.S.L; Albinsson I.; Mellander, B.E. Conductivity behaviour in novel quasi-solid-state electrolyte based on polyacrylonitrile and tetrahexylammonium iodide intended for dye sensitized solar cells. *J. Natn. Sci. Foundation Sri Lanka.* **2013**, 41 (3): 175-184.

6. Bandara, T.M.W.J.; Jayasundara, W.J.M.J.S.R.; **Dissanayake, M.A.K.L**.; Fernando, H.D.N.S.; Furlani, M.; Albinsson, I.; Mellander, B.-E. Quasi solid state polymer electrolyte with binary iodide salts for photo-electrochemical solar cells. *International Journal of Hydrogen Energy*. **2014**, 39, 2997 -3004.

7. **Benjamin, S.P**. On the crab spider genus *Angaeus* Thorell, 1881 (Araneae: Thomisidae). *Zootaxa*. **2013**. 3635, 071-080.

8. Buddhika U.V.A.; Athauda A.R.W.P.K.; **Kulasooriya S.A**.; **Seneviratne G**.; Abayasekara C.L. Emergence of diverse microbes on application of biofilmed biofertilizers to a maize growing soil. *Ceylon Journal of Science (Biological Science)*, **2013,** 42 (2), 39-47.

9. Chandrajith, R.; Barth, J. A.C.; **Subasinghe, N.D**.; Merten, D.; **Dissanayake, C.B**. Geochemical and isotope characterization of geothermal spring waters in Sri Lanka: Evidence for steeper than expected geothermal gradients. *J. Hydrology,* **2013**, 476, 360–369.

10. Chathuranga, P.K.D.; Priyantha, N.; Iqbal, S.S.; **Iqbal, M.C.M**. Biosorption of Cr(III) and Cr(VI) species from aqueous solution by *Cabombacaroliniana*: kinetic and equilibrium study. *Environmental Earth Sciences*. **2013**, 70(2), 661-671.

11. Choo, S.C.C.; Lee, Y.H.; **Waisundara, V.Y**. Evaluation and characterization of antioxidant activity of selected herbs and spices. *J. Nat. Remedies*. **2013**, 13, 95-103.

12. **Dissanayake, M.A.K.L**.; Thotawatthage, C. A.; **Senadeera, G.K.R**.; Bandara, T. M. W. J.; Jayasundara, W. J. M. J. S. R. ; Mellander, B.-E. Efficiency enhancement in dye sensitized solar cells based on PAN gel electrolyte with $Pr_4NI + MgI_2$ binary iodide salt mixture. *J Appl Electrochem*. **2013**, 43:891–901.

13. **Dissanayake, M.A.K.L**.; Rupasinghe, W. N. S.; Jayasundara, J. M. N. I.; Ekanayake, P.; Bandara, T. M. W. J.; Thalawala, S. N.; Seneviratne, V.A. Ionic conductivity enhancement in the solid polymer electrolyte PEO_9LiTf by nanosilica filler from rice husk ash. *J Solid State Electrochem*. **2013**, 17:1775–1783.

14. **Dittus, W. P. J.** Arboreal adaptations of body fat in wild toque macaques (*Macaca sinica*) and the evolution of adiposity in primates. *Am. J. Phys. Anthrop*. **2013**, 152:333-344. DOI: 10.1002/ajpa.22351

15. Gunathilaka, K.M.D.; **Ratnayake, R. R**.; **Kulasooriya, S. A**.; Karunaratne D. N. Evaluation of cellulose degrading efficiency of some fungi and bacteria and their biofilms. *Jour Natn Sci Foundation*, **2013**, 41 (2): 155 – 163.

16. Herath, H.M.L.I.; Senanayeke, D.M.N.; **Seneviratne, G**.; Bandara, D.C. Variation of biochemical expressions of developed fungal-bacterial biofilms over their monocultures and its effect on plant growth. *Tropical Agricultural Research.* **2013,** 24, 186–192.

17. Hobbs, B.A.; Fonseka, G.M.; Jones, A.G.; de Silva, S.N.; **Subasinghe, N.D.**; Dawes, G.; Johnson, N.; Cooray, T.; Wijesundara, D.; Suriyaarachchi, N.; Nimalsri, T.; PremathIlake, K.M.; Kiyan, D.and Khoza, D. Geothermal Energy Potential in Sri Lanka: A Preliminary Magnetotelluric Survey of Thermal Springs. *Jour. Geol. Soc. Sri Lanka*. **2013**, 15, 69-84.

18. Jayasundara, W.J.M.J.S.R.; Bandara, T.M.W.J.; Fernando, P.S.L.; Fernando, H.D.N.S.; **Dissanayake, M.A.K.L.**; Bandara, L.R.A.K.; Mellander, B.-E. Conductivity and Thermal Properties of PAN Based Polymer Electrolytes for Possible Application in Photo Electrochemical Solar Cells. *Journal of Electrical Engineering*. **2013**, 34-39.

19. Kumara, N.T.R.N.; Ekanayake, P.; Lim, A.; Louis Liew Yu Chiang.; Iskandar, M.; Lim Chee Ming.; **Senadeera, G.K.R.** Layered co-sensitization for enhancement of conversion efficiency of natural dye sensitized solar cells. *Journal of Alloys and Compounds.* 581, **2013**, 186-191.

20. Kuruppuarachchi, K. A. J. M.; **Seneviratne, G**.; Madurapperuma, B.D. Drought induced fine root growth and canopy green-up of tropical dry zone vegetations in Sri Lanka. *Journal of Tropical Forestry and Environment*. **2013,** 3, 17-23.

21. Kuruppuarachchi, K. A. J. M.; **Seneviratne, G**. Predicting above ground biomass increment of tropical forests from litter-fall. *Ceylon Journal of Science (Biological Science)*. **2013,** 42(1), 35-40.

22. Lee, Y.H.; **Waisundara, V.Y**. A comparative study on the antioxidant activity of commonly used South Asian herbs and spices. *J. Tradit. Complement. Med*. **2013**, 3, 263-267

23. Liyanage, M.; **Magana–Arachchi, D**; Chandrasekharan, N. Identification of Cylindrospermopsin and *Cylindrospermopsisr aciborskii* from Anuradhapura District, Sri Lanka. *Journal of Ecotechnology Research,* **2013**, 17[1], 23- 28.

24. **Magana-Arachchi, D.N**.; Wanigatunge, R.P. First report of genus *Chroococcidiopsis* (cyanobacteria) from Sri Lanka: a potential threat to human health. *Journal of the National Science Foundation of Sri Lanka*. **2013,** 41 (1), 65- 68.

25. **Nalaka, G. D. A.; Sivanathawerl, T.;** Iqbal, M. C. M. Scaling aboveground biomass from small diameter trees.*Tropical Agriculture Research***. 2013,** 24: 150-162.

26. **Nanayakkara, A**; Mathanaranjan T. Explicit energy expansion for general odd degree polynomial potentials, *Phys. Scr*. **2013** 88, 055004

27. **Nanayakkara, A**; Mathanaranjan T. Isospectralhermitian counterpart of complex non-Hermitian Hamiltonian *p2 – gx4 + a/x2*. *Can. J. Phys*. **2013,** 91, 599

28. **Nanayakkara, A**. Effects of complex time on periodic and non-periodic classical trajectories of 1-D Hamiltonian systems. *Can. J. Phys*. **2013**, 91,293

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15. IFS STAFF 2013

Director : Prof. C.B. Dissanayake
Secretary : Dr. P.S.B. Wanduragala

Research Staff

Research Professors

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

Senior Research Fellows

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

Research Fellows

Dr. R. Liyanage
Dr. R.R. Ratnayake
Dr. M. Vithanage
Dr. V.Y. Waisundara
Dr. H.W.M.A.C. Wijayasinghe

Visiting Research Professors

Prof. S.A. Kulasooriya
Prof. M.A. Careem

Visiting Associate Research Professor

Prof. G.K.R. Senadeera

Visiting Senior Scientist

Dr. W.P.J. Dittus

Visiting Research Fellow

Mr. J. Padmasiri

Research Assistants - Grade I

Dr. C.I. Clayton
Mr. J. Akilawasan
Ms. H.M. Liyanage
Mr. A. Manjceevan
Ms. M.P. Madanayake
Mr. W.W.M.A.B. Medawatte
Mr. C.A. Thotawatthage
Ms. Wanigatunge R.P.
Ms. Zahmeeth S.S.

Research Assistants - Grade I I

Bandara H.M.S.K.H.
Chathuranga P.K.D.
De Silva E.H.
De Silva A.G.D.D.
Ekanayake E.M.H.G.S.
Herath H.M.P.S.
Herath P.H.M.I.D.K.
Herath H.M.L.I.
Jayaratne S.L.
Jayaratne I.P.L.
Jayathilake H.A.P.P.B.
Karunawansha I.S.
Kathirgamanathan M.
Kehelpannala C.L.
Keerthiratne T.P.
Kumari J.M.K.W.
Kumarathilake S.M.P.R.
Kulatunga K.M.S.D.B.
Mayakaduwa S.S.
Nimalsiri T.B.
Padmathilake K.G.E.
Perera O.S.
Perera M.B.U.
Rupasinghe W.N.S.
Rajapaksha R.T.N.
Rajapaksha R.P.S.K.
Ranasinghe U.G.S.L.
Sandamali P.M.H.
Seneviratne S.M.M.P.K.
Suriyaarachchi N.B.
Wasalamuni W.A.D.D.
Weerasekera D.K
Wijesekara S.S.R.M.D.H.R.
Wijeratne W.M.K.T.
Wijesundara D.M.
Wijethunga S.H.D.P.

Technical Staff

Chief Technical Officers

Kulathunga M.N.B.
Weerakoon W.M.R.B.

Senior Staff Technical Officers

Aluthpatabendi D.
Athukorale N.P.
Herath H.M.A.B.
Jayasekara Banda W.
Jayaweera D.S
Karunaratne R.K.C.
Opatha S.
Pathirana A.K.
Perera R.S.M.
Sakalasooriya S.S.K.
Tumpela I.

Director's Office

Jeewa Kasthuri M.D.	Personal Secretary to the Chief Ex. Officer
Seneviratne O.W.K.	Stenographer Gr.II
Saranga R.H.G.	Internal Auditor
Gunasena C.O.	Management Assistant Grade III

Colombo Office

Rajapakse M.C.	Coordinator cum Scientific Officer
Gunawardena A.D.	Karyala Karya Sahayake/Driver

Library

Tilakaratne T.C.P.K. – Asst.Librarian

Accounts Division

Samarakkody P.S.S.	Deputy Accountant
Vithanage M.P.	Accounts Officer
Nissanka M.K.	Senior Staff Assistant – Book Keeper
Palliya Guruge M.P.	Senior Staff Assistant - Clerical
Gamalath T.P.	Management Assistant Grade III
Rathnayake R.M.V.P.	Staff Assistant – Clerical
Keshan M.K.D.	Management Assistant Grade III
Ariyaratne G.	Staff Assistant – Store Keeping
Perera M.A.P.	Office Machine Operator

Procument & Lab Stores Division

Perera W.D.S.P.	Laboratory Manager
Lakshmi Kumari D.M.K.	Senior Staff Technical Officer
Chandrakanthi G.W.R.P.	Senior Staff Assistant-Stenographer

Administration Division

Rajapaksha R.D.W.C.	Administrative Officer
Hettiarachchi T.P.	Senior Staff Assistant – Stenographer
Weerasooriya R.P.M.	Senior Staff Assistant - Clerical
Illangakoon C.	Staff Assistant - Stenographer
Ranasinghe C.	Staff Assistant – Receptionist
Gunathilake D.G.	Record Keeper Gr. I
Jayasekara D.J.M.W.P.	Machinist – Special Grade
Lal M.A.	Laboratory Attendant – Special Grade
Hapukotuwa R.B.	Laboratory Attendant – Special Grade
Kumara A.V.A.P	Machinist Gr. I
Dharmasena G.D.	Electrician Gr. II
Dorakumbura D.G.K.	Mason Gr. II
Herath Banda H.H.M.	Painter Gr.II

Transport Division

Dayaratne E.C.B.	Management Asst. III
Jayaweera A.B.G.W.	Driver – Special Grade
Somananda M.A.G.	Driver – Special Grade
Ariyawansa K.M.	Driver – Special Grade
Basnayake G.A.R.	Driver – Special Grade
Dayasiri M.G.	Driver – Special Grade
Nawarathne Y.G.	Driver - Special Grade
Gunawardena R.S.K.	Driver - Gr..I
Gunasekara K.G.T.B.	Driver - Gr. I

Science Dissemination Unit

Dr. Tilakaratne C.T.K .- Coordinator
Samarakoon K.I.K. - Stenographer Gr. II

INSTITUTE OF FUNDAMENTAL STUDIES - SRI LANKA

SIGNIFICANT ACCOUNTING POLICIES - YEAR ENDED 31ST DECEMBER 2013

(1) GENERAL ACCOUNTING POLICIES

1.1 The financial statements have been prepared on the basis of historical costs in accordance with the Srilanka Public Sector Accounting Standards for the Accrual basis accounting and no adjustments have been made for inflatory factors affecting these accounts, instead of Motor Vehicle re-valuation according to the special Re-valuation committee.

1.2 Similarly Laboratory Equipment, Machinery Tools & Implements, Refrigerators, Air Conditioners, Communication Equipment, Office & Miscellaneous Equipment, Sports Items were re- valued by the Special Re-valuation Committee and there is no inflator factors affecting to the accounts in 2011

1.3 The value of Revaluation of Fixed Asset in 2011 has been shown as Revaluation Reserve being adjusted by Institute Fund Account.

1.4 Previous year figures and phrases have been re-arranged wherever necessary to conform to the current presentation.

1.5 CONVERSION OF FOREIGN CURRENCIES

All foreign exchange transactions are converted of the rate of exchange prevailing at the time the transactions were effected. Non-resident foreign currency account balance has been translated at the rate of exchange prevailing at the date of balance sheet.

1.6 TAXATION

Under the provision of sections 8(a) (xxxix) and 42 (ff) of the Inland Revenue Act No. 28 of 1979 (as amended) the Institute is exempted from income tax in Sri Lanka.

(2) ASSETS AND BASES OF THEIR VALUATION

2.1 STOCKS:

Stocks have been valued at historical cost basis and all issues are valued at FIFO Basis.

2.2 FIXED ASSETS:

2.2.1 The cost of fixed assets is the cost of purchase or construction together with any incidental expenses thereon. The fixed assets are recorded at cost and accumulated depreciation which is provided in the depreciation on the basis specified in 2.2.2

2.2.2 DEPRECIATION OF FIXED ASSETS

The provision for depreciation has been calculated on the cost of fixed assets in order to write-off such costs over the estimated useful lives as follows:

Motor vehicles	20%
Library books	33.33%
Building	10%
Lab Equipment	10%
Sports goods	33.33%
Computers	25%
Furniture & fittings	10%

	Communication	10%
	Air - Conditioners	10%
	Refrigerators	10%
	Machinery Tools & Implements	10%
	Office & Miscellaneous	
	Room Linen	33.33%
	Crockery Cutlery & Canteen Equipment	33.33%
*	Safety Equipment	10%
	Office Equipment	20%
	Sundry Assets	10%
	Expandable Assets	10%

***** Safety Equipment - Rate of depreciation had been changed from 33.33% to 10% with effect from 1999.

The method for depreciation has been changeed in year 2012, previously full year's depreciation has been provided for items in the year of disposal while no depreciation is provided on the item purchased. The new method is on the date of item purchased to the date of disposal.

According to change of depreciation method, the sum of Rs. 1,577,004.39 has been effected to the net deficit in year 2012 in shown under prior year adjustment.

2.2.3 The Accumulated depreciation has been corrected due on 31st December 2011 to meet the Fixed Assets of the Institution by that date.

2.3 INVESTMENT

Employer's and employees' contributions made towards the IFS provident fund has been invested in fixed deposits at the National Savings Bank.

2.4 Contribution made towards Consumption Loan Fund has been deposited in Savings Account at the National Savings Bank.

(3) LIABILITIES AND PROVISIONS

3.1 All known liabilities and provisions as the date of the balance sheet have been provided for in the accounts.

3.2 RETIREMENT GRATUITY

Provision is made in these Accounts for retirement gratuity payable under the payment of Gratuity Act No.12 of 1983 in respect of employees with 5 or more years of continued service in the Institute. This item is grouped under deferred liabilities in the balance sheet.

3.3 I.F.S. PROVIDENT FUND

Members' fund as at 31st December 2013 are shown under specified funds in the balance sheet.

4. REVENUE RECEIPTS

4.1 GOVERNMENT GRANT

Government grant received during the year under review towards the recurrent expenditure has been charged to income and expenditure account for the year. Total revenue and capital funds of the Institute accumulated from the previous years have been shown as Institute funds in the balance

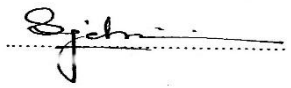
sheet.

4.2 FOREIGN AND OTHER GRANTS

All foreign and other monetary grants received during the year, are dealt with by charging to the income and expenditure account to the extent of such grants recognized in the financial statements do match with the associated cost incurred during the year. Unspent grants during the year are shown under specified funds and grants in the balance sheet.

4.3 RESEARCH GRANT FUND

The un-utilized specified grant balances have been shown as in the Research Grant Fund under specified fund in the Balance Sheet.



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Deputy Accountant

INSTITUTE OF FUNDAMENTAL STUDIES

SRI LANKA

STATEMENT OF FINANCIAL POSITION AS AT 31.12.2013

	NOTE	SLRs 2013	SLRs 2012
ASSETS			
CURRENT ASSETS			
CASH AND BANK BALANCES	1	48,504,610.47	31,906,821
DEPOSITS PREPAYMENTS & ADVANCES	2	8,245,472.23	37,533,013
DISPOSABLE OF FIXED ASSETS		24,915,351.37	26,624,391
FESTIVAL ADVANCE FUND INVESTMENT		255,000.00	250,000
CONSUMPTION LOAN FUND INVESTMENT		192,962.16	151,775
INTEREST RECEIVABLE FOR FIXED DEPOSITS		4,452,481.52	2,767,317
STAFF CONSUMPTION LOAN	3	3,948,038.00	3,817,263
DEBTORS AND OTHER RECEIVABLE	4	186,926.39	237,671
STOCKS	5	2,042,252.86	2,491,185
		92,743,095.00	**105,779,436**
NON-CURRENT ASSETS			
WORK IN PROGRESS (NEW BUILDING)		62,920,000.00	-
PROVIDENT FUND INVESTMENT	6	40,150,001.93	36,810,789
TRAINING CAPACITY		823,697.40	815,697
PROPERTY, PLANT AND EQUIPMENT	7	255,539,911.44	213,685,672
MAPPING REPORT		1,097,477.65	-
MODEL OF LAND		37,500.00	37,500
		360,568,588.42	**251,349,658**
TOTAL ASSTES		**453,311,683.42**	**357,129,094**
LIABILITIES			
CURRENT LIABILITIES			
ACCOUNTS PAYABLE	8	1,386,950.46	473,705
ACCRUED EXPENSES	9	1,907,445.69	1,487,510
		3,294,396.15	**1,961,215**
NON CURRENT LIABILITIES			
SPECIFIED FUNDS & GRANTS	10	69,261,002.20	56,995,918
DIFFERED LIABILITIES	11	15,640,908.99	14,141,405
		84,901,911.19	**71,137,323**
TOTAL LIABILITIES		**88,196,307.34**	**73,098,538**
NET ASSETS		**365,115,376.08**	**284,030,556**
NET ASSETS/EQUITY			
CAPITAL FUND - SPENT	12	262,427,055.62	212,961,539
- UNSPENT		13,594,361.75	6,454,323
PRESIDENT'S FUND - SPENT		7,078,501.15	7,078,501
ASSET REVALUATION RESERVE		122,463,619.32	122,463,619
INSTITUTE FUND		(40,448,161.76)	(64,927,426)
TOTAL NET ASSETS/EQUITY		**365,115,376.08**	**284,030,556**

Director	Secretary	Deputy Accountant

INSTITUTE OF FUNDAMENTAL STUDIES

SRI LANKA

STATEMENT OF FINANCIAL PERFORMANCEFOR THE YEAR ENDED 31.12.2013

	NOTE	SLRs 2013	SLRs 2012
OPERATING REVENUE			
RECURRENT GRANT		117,068,000.00	104,000,000
OTHER INCOME	13	10,821,016.46	17,987,090
		127,889,016.46	**121,987,090**
EXPENDITURE			
PERSONAL EMOLUMENTS	14	79,703,841.32	70,193,328
TRAVELLING	15	777,472.40	514,430
SUPPLIERS & CONSUMABLE	16	9,792,683.62	9,206,321
MAINTENANCE	17	2,927,575.19	3,328,066
CONTRACTUAL SERVICES	18	14,366,457.87	13,572,683
DEPRECIATION		27,759,753.84	26,784,232
OTHER EXPENSES	19	16,758,979.03	22,234,468
TOTAL OPERATING EXPENSES		**152,086,763.27**	**145,833,528**
DEFICIT FROM OPERATING ACTIVITIES		(24,197,746.81)	(23,846,438)
FINANCE COST			
LOSS OF DEPOSAL OF FIXED ASSETS		(1,570,623.42)	(147,086)
PRIOR YEAR ADJUSTMENT	20	(2,396,227.21)	(56,517)
NET DEFICIT FOR THE YEAR		**(28,164,597.44)**	**(24,050,041)**

INSTITUTE OF FUNDAMENTAL STUDIES
SRI LANKA

STATEMENT OF CHANGES IN NET ASSETS/EQUITY FOR THE YEAR ENDED 31.12.2013

ATTRIBUTABLE TO OWNERS OF THE CONTROLLING ENTITY					
	CONTRIBUTED CAPITAL	PRESIDENT FUND	REVALUVATION SURPLUS	INSTITUTE FUND	TOTAL NET ASSEST/EQUITY
BALANCEAS AT 01 JANUARY 2013	219,415,862.37	7,078,501.15	122,463,619.32	(64,927,426.22)	284,030,556.62
FIXED ASSET PURCHASE FROM GRANT	-	-	-	2,558,294.68	2,558,294.68
ADDITION DURING THE YEAR TO INSTITUTE FUND	-	-	-	50,085,567.22	50,085,567.22
DEFICIT FROM OPERATING ACTIVITIES	-	-	-	(24,197,746.81)	(24,197,746.81)
LOSS OF DESPOSAL LOSS OF FIXED ASSETS	-	-	-	(1,570,623.42)	(1,570,623.42)
PRIOR YEAR YEAR ADJUSTMENT	-	-	-	(2,396,227.21)	(2,396,227.21)
CAPITAL FUNDS RECEIVED FROM GOVERNMENT & OTHER SOURCES	56,605,555.00	-	-	-	56,605,555.00
BALANCE AS AT 31 DECEMBER 2013	**276,021,417.37**	**7,078,501.15**	**122,463,619.32**	**(40,448,161.76)**	**365,115,376.08**

INSTITUTE OF FUNDAMENTAL STUDIES

SRI LANKA

STATEMENT OF CASH FLOW FOR THE YEAR ENDED 31.12.2013

	SLRs. 2013		SLRs. 2012
Cash-Flow from Operating Activities			
Deficit for ordinary activities	(28,164,597)		(24,050,041)
Add/Less : Net adjustment to the fund	50,085,567		14,816,137
		21,920,970	(9,233,903)
Not involving movement of cash			
Depreciation	27,759,754		26,784,232
Provision for Gratuity	2,085,929		1,016,588
Adjustments in respect of Capital Expenditure	-		-
incurred by Projects	2,558,295		1,245,227
Adjustments to Provision for Depreciation	1,574,968		(3,268,811)
(Increase)/Decrease Disposable of Fixed Assets	1,709,040		(26,624,391)
(Increase)/Decrease Staff Consumption Loan	(130,775)		(169,522)
(Increase)/Decrease Stocks	448,932		688,656
(Increase)/Decrease Debtors and other Receivable	50,745		(111,458)
(Increase)/DecreaseWorking in progress (New Building)	(62,920,000)		
(Increase)/Decrease Festival Advance Inv.Fund	(5,000)		(3,000)
(Increase)/Decrease Consumption Loan Inv.Fund	(41,187)		
(Increase)/Decrease Int.rec.for Fixed Deposits	(1,685,165)		(841,443)
(Increase)/Decrease Deposits, prepayment and Advances	29,287,541		(26,944,809)
Disposable of Fixed Assets			
Cash in Hand for Festival Advance			
Increase/(Decrease) Accounts Payable	913,245		(955,928)
Increase/(Decrease) Accrued Expenses	419,936		(123,412)
Gratuity Paid	(586,425)		(1,434,873)
Adjustment of Fixed Assets	(1,709,040)		
Loss on Disposal of Fixed Assets	1,570,623	1,301,416	147,086
Net Cash flow from Operating Activities		**23,222,386**	(39,829,762)
Cash Flow from Investing Activities			
Purchase of Fixed Assets	(71,188,961)		(26,199,678)
Training & Capacity	(8,000)		(46,500)
Mapping Report	(1,097,478)		1,366,835
Adjustments to Fixed Assets			14,693,202
Investments made- Provident Fund	(3,339,213)		(4,983,714)
- Consumption Loan Fund			6,884
Write off Over Spent Grant for Reimbursement			
		(75,633,652)	
Net Cash Flow from Investing Activities		**(52,411,266)**	(54,992,732)

Cash Flows from Financing Activities			
Government Capital Contribution	56,605,555		54,518,000
Specific Funds and Grants	12,265,084		225,182
Over-Spent Grant Reimbursement			-
Proceed on Sales of fixed Assets	138,416	69,009,055	5,100
Net increase/ (Decrease) in cash and cash equivalent		16,597,789	(244,451)
Cash and cash equivalent at beginning of period		31,906,821	32,151,271
Cash and cash equivalent at the end of the period		**48,504,610**	31,906,821

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013		
NOTE 1		
CASH AND BANK BALANCES		
	SLRs	**SLRs**
	2013	**2012**
National Savings Bank, Kandy - EPF Account	9,416,248.22	3,067,994
A/C No 1-0015-01-02989		
National Savings Bank, Kandy - Research Fund	60,724.39	57,770
A/C No 1-0015-01-03152		
National Savings Bank, Kandy -Consumption	192962.16	151,775
Loan Fund A/C No 1-0015-109-1808		
Bank of Ceylon, Kandy, -A/C NO RFC/162747	5,773,438.50	5,387,729
Bank of Ceylon, Kandy, A/C No 32794	2,414,937.85	2,174,130
Bank of Ceylon, Kandy, A/C No 32795	16,627,197.39	14,106,685
Bank of Ceylon, Kandy, A/C No 32779	14,019,101.96	6,960,738
	48,504,610.47	**31,906,821**
NOTE 2		
DEPOSITS PREPAYMENTS & ADVANCES		
Refundable Deposit (Note 2A)	417,100.00	414,100
Prepayment Local (Note 2B)	959,912.72	856,420
Prepayments & Advance Foreign (Note 2C)	2,948,841.49	447,734
Prepayments & Advance Letter of Credit (Note 2D)	1,998,158.00	-
Advance of Book Rack - Natural Products	-	5,490
Advance of Stand - Structural Geology	4,960.00	4,960
Advance of Director, Building Dep.	1,782,831.13	1,782,831
Advance of Director, Building Dep.	-	32,920,000
Advance of Hydraulic Jack	4,000.00	4,000
Advance of Mapping	-	1,097,478
Contribution from Welfare	129,668.89	-
	8,245,472.23	**37,533,013**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 2A

REFUNDABLE DEPOSIT

	SLRs 2013	SLRs 2012
Ceylon Electricity Board	275,000.00	275,000
Sri Lanka Telecom	5,000.00	5,000
Kandy Municipal Council	20,000.00	20,000
Ceylon Oxygen Ltd.	32,100.00	32,100
Colombo Gas Company	2,000.00	2,000
Lanka Internet Service	1,000.00	1,000
Kandy Tyre Rebuilding Co.	50,000.00	50,000
D.A. Epa & Sons (Pvt) Ltd	3,750.00	3,750
C.I.S.I.L.	15,000.00	15,000
Shell Gas Lanka Limited	3,750.00	3,750
MTN Network Pvt. Ltd.	2,500.00	2,500
Dialog Telecom Package	4,000.00	4,000
America Preime Water Systems	3,000.00	-
	417,100.00	**414,100**

NOTE 2B

PREPAYMENT LOCAL

	SLRs 2013	SLRs 2012
American Chemical Society	97,276.67	141,893
American Physical Society	25,406.67	23,867
American Society For Microbiology	-	50,485
American Association	15,071.62	21,123
The American Archeological Society	-	12,532
Animal Behavior Society	-	7,125
British Society of Soil Scientist	-	10,886
Chief Post Master Kandy	2,500.00	2,500
Defence Levy - Director General Custom	250,182.46	-
Indian Academic of Science	-	17,000
Staff Insurance	427,108.88	400,000
Metropolitan Office Pvt Ltd	-	12,880
Macmillan Subscriptions Ltd	9,255.14	29,721
National Geographic Society	7,881.50	7,796
New Scientist	20,190.67	14,471
Portland Customer Service	-	6,732
S.B. Freight Services	47,679.79	3,190
Scientific America	-	6,341
JohnKeells Office Automation (Pvt.) Ltd.	43,958.32	22,333
Oxford Journal	-	9,224
Soil Science Society of America	-	29,244
Superintendent of Government Publications Bureau	-	13,500
Sri lanka insurance	-	10,517
Society for Conservation Biology	-	3,060
Director General Government Information	448.00	-
Peoples Bank / Economic Review	135.00	-
Perdium for Indo- SL Grant	12,593.00	-
Wijjaya Newspapers	225.00	-
	959,912.72	**856,420**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 2C

ADVANCES (FOREIGN PURCHASE)

	SLRs 2013	SLRs 2012
A J Cope & Sons Ltd.	590,603.36	-
Amersham Life Science Ltd	1,546.27	1,546
Bacheman California	11,873.65	11,874
Biomatter Ltd	28,868.75	-
Cardolite Ltd	569,541.30	-
Cole Promer International	73,447.88	-
Elsevier Science	61,008.50	61,008
Fisher Scientific UK	425,015.28	-
Forestry Suppliers	104,034.36	-
Fluka Chemical	34,771.47	34,771
Ge. Health Care, Bio- Science	-	138,872
John matty Chemicals India (pvt) Ltd	157,150.24	-
Kluwer Academic	47,733.25	47,733
Memmert GMBH	198,154.41	-
M.J. Patterson (Scientific) Ltd	20,447.53	20,448
Sigma Aldrich	32,616.72	32,617
Shirmadzu (Asia Pacific)	-	86,838
U.S. Speaker	13,159.78	-
Ven India Imports & Export	1,167.50	1,167
VWR International Ltd	567,974.04	1,133
Wageningen Agricultural University Netherlands	9,727.20	9,727
	2,948,841.49	**447,734**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 2D

PREPAYMENTS & ADVANCES (LETTER OF CREDIT)

	SLRs 2013	SLRs 2012
LC NO-KN/SIL/011/384	1,998,158.00	-
	1,998,158.00	**-**

NOTE 3

STAFF CONSUMPTION LOAN

	SLRs. 2013	SLRs 2012
M. D. Jeewa Kasthuri	136,635.00	176,655
D. G. Gunathilake	159,125.00	16,620
D. G. K. Dorakumbura	-	16,540
G. Ariyarathne	93,280.00	133,300
A. V. A. P. Kumara	61,670.00	93,950
R. B. Hapukotuwa	70,675.00	107,575
G. W. R. P. Chandrakanthi	119,960.00	159,980
R. M. V. P. Rathnayake	116,675.00	183,335
T. C. P. Thilakarathne	-	6,120
M. A. P. Perera	66,785.00	105,005
M. P. P. Guruge	103,285.00	143,305
M. A. Lal	169,953.00	3,960
R. S. M. Perera	-	7,350
G. D. Dharmasena	175,910.00	13,440
D. Aluthpatabendi	126,630.00	166,650
N. P. Athukorale	86,990.00	110,198
A. K. Pathirana	106,620.00	146,640
D. J. M. W. P. Jayasekara	73,270.00	113,290
I. Thumpela	-	133,300
R. B. Weerakoon	94,455.00	161,115
R. K. C. Karunarathne	93,280.00	133,300
D. M. K. Lukshmi Kumari	-	14,410
S. Opatha	200,000.00	47,650
W.G. Jayasekara Banda	129,965.00	169,985
K. M. Ariyawansa	63,650.00	89,150
M. A. G. Somananda	50,540.00	75,860
H. W. M. R. P. M. Weerasooriya	156,645.00	196,665
M. N. B. Kulatunge	109,955.00	149,975
W. D. S. P. Perera	60,500.00	126,500
K. G. T. B. Gunasekara	196,665.00	23,210
R. S. K. Gunawardene	78,125.00	115,625
P.S.S. Samarakkody	143,305.00	183,325
C.Illangakoon	159,980.00	200,000
D.S.Jayaweera	139,970.00	179,990
H.M.A.B. Herath	73,270.00	113,290
S.S.K. Sakalasooriya	176,655.00	-
A.D. Gunawardana	189,995.00	-
G.R.A. Basnayake	163,620.00	-
	3,948,038.00	**3,817,263**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 4

DEBTORS & OTHER RECEIVABLES

		SLRs 2013	SLRs 2012
Staff Debtors - Festival Advance	(Note 4A)	45,000.00	51,500
Advances & Other Receivables	(Note 4B)	141,926.39	186,171
		186,926.39	**237,671**

NOTE 4A

STAFF DEBTORS - FESTIVAL ADVANCES

A.D. Gunawardane	-	1,000
A.K. Pathirana	1,000.00	1,000
A.V.A.P. Kumara	1,000.00	1,000
M.B.U. Perera	-	1,000
C. Illangokoon	1,000.00	1,000
D. Alupthpatabendi	1,000.00	1,000
D.G. Gunathilaka	1,000.00	1,000
D.S. Jayaweera	1,000.00	1,000
G.A.R. Basnayake	1,000.00	1,000
G.D. Dharmasena	1,000.00	1,000
D.J.M.W. P. Jayasekara	1,000.00	1,000
E.C.B. Dayarathna	-	1,000
G.W.R. Chandrakanthi	1,000.00	1,000
H.H. Herath Banda	-	1,000
H.M.A.B. Herath	1,000.00	1,000
H.W.R.P.M. Weerasooriya	1,000.00	1,000
I. Tumpela	1,000.00	1,000
I.P.L.Jayarathna	-	1,000
K.G.T.B. Gunasekera	1,000.00	1,000
K.I.K. Samarakoon	1,000.00	1,000
Lakshmi Kumari	1,000.00	1,000
M. A. G. Somananda	1,000.00	1,000
M.K. Nissanka	1,000.00	1,000
M.A. Lal	1,000.00	1,000
M.A.P. Perera	1,000.00	1,000
M.D. Jeewa Kasthuri	1,000.00	1,000
M.G Dayasiri	1,000.00	1,000
M.P. Palliyeguruge	1,000.00	1,000
M.G.K. Meegahakumbura	-	1,500
M.K.D. Keshan	1,000.00	1,000
M.P. Vithanage	-	1,000
N.P. Athukorale	1,000.00	1,000
O.W.K. Senevirathne	1,000.00	1,000

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

	SLRs	SLRs
	2013	2012
P.S.S. Samarakkody	1,000.00	1,000
R. Hapukotuwa	1,000.00	1,000
R.K.C. Karunaratne	1,000.00	1,000
R.S.K. Gunawardena	1,000.00	1,000
R.M.V.P. Rathnayaka	1,000.00	1,000
R.S.M. Perera	1,000.00	1,000
R.B. Weerakoon	-	1,000
R.D.W.C. Rajapaksha	1,000.00	1,000
R.G.H. Saranga	1,000.00	1,000
S. Opatha	1,000.00	1,000
S.K. Sakalasooriya	-	1,000
T.C.P. Tilakaratne	1,000.00	1,000
T.P. Wijewickrama	1,000.00	1,000
T.P. Gamalath	1,000.00	1,000
U.V.A. Buddhika	-	1,000
W. D. S. P. Perera	1,000.00	1,000
W.G. Jayasekera	1,000.00	1,000
Y.G. Nawartne	-	1,000
W.W.M.A.B. Medawatta	1,000.00	-
E.M.H.G.S. Ekanayake	1,000.00	-
C.O. Gunasena	1,000.00	-
P.S.B. Waduragala	1,000.00	-
K.M. Ariyawanse	1,000.00	-
	45,000.00	**51,500**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 4B

ADVANCES & OTHER RECEIVABLES

	SLRs 2013	SLRs 2012
P.K.D. Chathuranga	18,000.00	2,000
K.I.K.Samarakoon	-	20,000
Silverstone Ltd	47,500.00	-
Stamp Imp rest	6,500.00	6,500
T.H.N.G.Amaraweera	-	1,105
I.F.S. E.P.F.1%	55,398.43	27,157
I..Tumpale	-	14,979
E.Dayaratne	-	4,590
Accomadation	7,500.00	-
N.S.F.	-	25,837
Ministry of science & Technology	7,027.96	84,003
	141,926.39	**186,171**

NOTE 5

STOCKS

Chemical Glassware & Labware	1,373,078.08	1,629,040
Stationery and Sundry Stores	263,561.45	310,147
Publications	154,117.20	262,807
Consignee Stock - Publications	17,405.84	17,406
Building Maintenance	234,090.29	271,785
	2,042,252.86	**2,491,185**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 6

PROVIDENT FUND INVESTMENT

	CERTIFICATE NO.	**SLRs 2013**	**SLRs 2012**
1	200-15-03-0479-4	3,911,242.60	3,603,172
2	200-15-03-0478-6	3,911,242.60	3,603,172
3	200-15-03-0477-8	3,911,242.60	3,603,172
4	200-15-03-0480-8	3,911,242.60	3,603,171
5	200-15-03-13793	2,385,524.00	2,153,000
6	200-15-03-0494-8	3,813,457.52	3,527,712
7	200-15-02-9758-5	2,487,462.66	2,291,536
8	2-0015-14-16561	1,870,987.45	1,723,618
9	2-0015-14-16545	1,870,987.45	1,723,618
10	2-0015-14-16570	1,870,987.45	1,723,618
11	2-0015-03-13718	3,564,225.00	3,255,000
12	2-0015-03-17179	3,386,400.00	3,000,000
1134	2-0015-03-14510	3,255,000.00	3,000,000
		40,150,001.93	**36,810,789**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 7

FIXED ASSETS

COST

(SL Rs)

DEACRIPTION	TOTAL AS AT 01.01.2013	ADDITIONS	ADJUSTMENT/ DISPOSABLE	TOTAL AS AT 31.12.2013
Land	28,622,151.00	-	-	28,622,151.00
Buildings	29,728,586.91	-		29,728,586.91
Laboratory Equipment	159,862,672.57	59,164,532.06	-	219,027,204.63
Machinery Tools & Implements	754,039.28	10,955.00	-	764,994.28
				-
Motor Vehicles	20,268,108.55	306,155.00	-	20,574,263.55
Library Books	12,177,572.15	545,055.86	-	12,722,628.01
Refrigerators	1,145,555.38	536,925.00	-	1,682,480.38
Air Conditioners	4,569,716.61	226,891.19	-	4,796,607.80
Communication Equipment	843,995.42	27,190.00	-	871,185.42
Computers & Printers	16,205,410.47	1,559,295.00	-	17,764,705.47
Furniture & fittings	3,132,442.24	176,044.50	-	3,308,486.74
Sport Items	13,480.00	-	-	13,480.00
Office & Miscellaneous Equipment	10,307,951.90	8,635,917.16	-	18,943,869.06
	287,631,682.48	**71,188,960.77**	-	**358,820,643.25**

DEPRECIATION

DESCRIPTION	TOTAL AS AT 01.01.2013	CHARGE FOR THE YEAR	ADJUSTMENT/ DISPOSABLE	TOTAL AS AT 31.12.2013
Buildings	18,805,435.82	1,206,235.23		20,011,671.05
Laboratory Equipment	28,849,396.31	17,205,150.90	907,548.80	46,962,096.01
Machinery Tools & Implements	185,683.93	77,153.07	307.44	263,144.44
				-
Motor Vehicles	5,238,754.75	1,289,952.94	17,857.36	6,546,565.05
Library Books	10,622,574.62	934,633.70	175,182.03	11,732,390.35
Refrigerators	171,822.04	151,185.92	8,166.98	331,174.94
Air Conditioners	905,161.36	475,382.71	7,622.94	1,388,167.01
Communication Equipment	49,920.46	92,788.89	41,104.42	183,813.77
Computers / Printers	6,121,091.35	3,929,393.49	372,852.78	10,423,337.62
Furniture & fittings	366,967.74	324,440.39	2,633.18	694,041.31
Sport Items	12,260.00	610.00	-	12,870.00
Office & Miscellaneous Equipment	2,616,941.90	2,072,826.60	41,691.76	4,731,460.26
	73,946,010.28	**27,759,753.84**	**1,574,967.69**	**103,280,731.81**
Written down value	**213,685,672.20**			**255,539,911.44**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 8

ACCOUNTS PAYABLE

	SLRs 2013	SLRs 2012
Creditors - Suppliers & Services (Note 8A)	1,253,975.74	275,975
Other Creditors and Payable (Note 8B)	132,974.72	197,730
	1,386,950.46	**473,705**

NOTE 8A

CREDITORS-SUPPLIERS & SERVICES

Dr. R. Rathnayaka	11,519.10	-
Kandy Tyre Rebuilding Co. Ltd	75,552.40	81,517
Commissioner General Inland Revenue Stamp	-	10,070
Commissioner General Inland Revenue Tax	-	15,025
T. Gamini	58,500.00	36,100
Mr.Nugaliyadda	-	49,900
T.B.Nimalasiri	-	1,000
Haji M.K.M. Hasson & Sons	4,930.00	-
Hemsons International (Pte) Ltd	95,737.60	-
Srilanka Institute of Nano Technology	-	24,000
Organic Trading (Pvt) Ltd.	42,884.80	-
Exodus Labtech 9pvt0 LTD	-	3,920
Central Agencies (pvt) ltd	-	9,856
W.G. Jayasekara	3,491.30	-
R.D.W.C. Rajapakshe	230.00	-
R.G.K. Kumara	5,000.00	-
Dr. M. Vithanage	3,735.00	-
Dr. Benjamin	800.00	-
K.I.K. Samarakoon	920.00	-
Namal Athukorala	2,340.00	-
D.G. Gunathilake	545.00	-
S.B. Fright Service	40,582.00	-
R.K.C. Karunaratne	1,582.25	-
C.A. Thotawattage	26,982.90	-
Prof. L. Dissanayake	19,347.00	-
S.L. Jayarathne	19,347.00	-
O.S. Perera	38,827.48	-
Dr. R. Liyanage	41,172.52	-
kundasale Auto Service	19,838.00	-
ACE Internatinal Care	23,096.58	-
Dr. M.C.M. Iqbal	56,153.60	-
Prof. U.L.B.Jayasinghe	24,338.20	-

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

	SLRs 2013	SLRs 2012
Dr. A. Wijesinghe	4,547.12	-
Jeewa Kasthuri	3,500.00	-
M.A.G. Somananda	400.00	-
L. Wenkdasamy	2,487.00	-
Saman Priyadeva	1,600.00	-
Dinapaala (pvt) Ltd	36,250.00	-
R.S.KJ.Gunawardena	400.00	-
Green Park Holding	22,700.00	-
Royal Garden Hotel	86,285.00	-
Sri Ramya Hotel & Bakers	30,000.00	-
Solvem Trading Company	5,100.00	-
Ampitiya Auto Care	16,860.00	-
Indra Motor Spares (Pvt) Ltd	-	4,995
IFS Welfare Association	129,668.89	-
Analytical Instruments (Pvt) Ltd	296,725.00	28,777
The International Hardware Store	-	7,895
Atlas Electricals	-	2,920
	1,253,975.74	**275,975**

NOTE 8B

OTHER CREDITORS & PAYABLE

	SLRs 2013	SLRs 2012
EPF Payable	-	540
ETF Payable	-	74
Retention Money Payable	-	61,546
NRC Rent (Refundable Deposit)	90,000.00	90,000
Disposable Item (Refundable Deposit)	900.00	3,470
Malwatte Contractors	27,000.00	27,000
Sooner Scientific	14,968.82	14,969
Inland Revenue stamp	-	25
Inland Revenue tax	105.90	106
	132,974.72	**197,730**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013		
	SLRs	**SLRs**
	2013	**2012**
NOTE 9		
ACCRUED EXPENSES		
Traveling & Subsistence	5,400.00	800
Government Audit Fees	302,592.00	490,000
Temporary Staff Allowance - IFS	85,930.00	52,335
Temporary Staff Allowance - Grant	374,045.47	-
Communication	46,270.90	46,235
Overtime - IFS	90,477.61	63,809
Overtime - Grant	11,311.82	-
Security Services	163,585.97	163,545
Welfare	93,934.00	78,899
General Upkeep - Janitorial	59,963.75	54,320
General Upkeep - Garden Maintenance	39,292.25	31,125
General Upkeep - Catering	25,000.00	25,000
Water Charges	141,684.52	42,455
Internet	101,271.97	110,189
Salary - H. Jayasekera	-	2,457
Visiting Salary-Prof. S.A. Kulasooriya	36,444.55	44,199
Electricity	276,060.88	244,629
Paper Bill	-	1,520
Transport	42,000.00	-
Stamp Duty	12,180.00	-
Miscellaneous	-	8,240
Visiting Salary - J.P. Padmasiri	-	8,853
Library Book	-	3,240
Periodical &Journal	-	15,660
	1,907,445.69	**1,487,510**

NOTES TO THE ACCOUNTS FOR T

NOTE 10

SPECIFIED FUNDS & GRANTS

	SLRs 2013	SLRs 2012
I. F. S. Provident Fund	54,289,790.55	42,920,909
Retired Members Fund	2,153,269.66	1,908,712
Festival Advance Fund	255,000.00	250,000
Consumption Loan Fund	192,962.16	151,775
Specified Grants (NOTE-10A)	-	10,706,795
Research Grants Fund	1,663,184.39	1,224,721
	58,554,206.76	**57,162,912**

NOTE 10A

SPECIFIED GRANT BALANCES

School Science Programme	12,257.04	80,824
Best Grant	62,412.22	62,412
RG/2006/AASR/04 - Dr. G. Seneviratne	54,505.83	54,506
RG/2006/EB/08	35,522.39	35,522
Sample Analysis	59,117.00	-
Scientia Magazine	174,705.75	230,006
CCD Murunga	-	12,634
Saitama University	-	357,829
Copenhagen University		1,082
Dayata kirula	13,825.28	-
Bioassaya	49,442.83	49,443
Vidu Kirana	144,992.15	335,185
Annual Review	10,000.00	-
Nawala Open University	-	31,778
Nawala Open University	-	61,020
Kalaniya University -Dr	-	45,000
Sola- Asia	310,912.75	310,913
Tube Chanel	300,000.00	-
Symposium	306,195.07	596,280
University Of Sydney	475,742.20	1,233,183
Tranning Programme	19,858.50	-
C.K.D. Wiyaba	-	146,159
RG/2011/BS/01	116,117.98	118,333
HETC Project	126,689.79	239,782
Anuradapura District Tank	2,400,000.00	2,400,000
Water Analized -Dr Benjamin	-	5,995
RG/2011/AG/09 - Dr. R. Liyanage	91,557.02	161,987
IFS Sweeden Grant	391,436.05	426,437
Rhizobium Grant	1,721,986.32	277,746

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

	SLRs	SLRs
Mahaweli Irrigation - Prof.Kulasooriya	-	83,022
PV Workshop - Prof. L. Dissanayake	40,031.78	42,432
RG/2012/EQ/03 - Prof. L.Dissanayake	-	576,224
Short Course	-	-
RG/2012/BS/06 - NSF - Prof. N.S. Kumar	364,482.57	280,463
Rhizobium Master Class- Prof. Kulasooriya	-	482,540
NSF/SCH/2012/02 - Postgraduate Research	263,681.73	300,000
RG/2012/NRB/03 - Dr. N.D. Subasinghe	24,996.96	316,438
RG/2012/BS/04 - Prof. L.Dissanayake	194,289.64	535,000
Water Quality - Mr. Padmasiri	39,356.32	7,200
Tokyo Cement - Dr. Iqbal	520,245.00	11,979
NSF - RG/2012/AG/01 - Dr. Jayasinghe	323,848.81	630,447
NSF/ESA/01	977,439.67	-
Spectra Industries	290,000.00	-
MTR Indian Grant	791,146.79	-
	10,706,795.44	**10,539,801**

NOTE 11

DIFFERED LIABILITIES

Provision for Retirement Gratuity	15,640,908.99	14,141,405
	15,640,908.99	**14,141,405**

NOTE 12

CAPITAL FUND SPEND AND UNSPENT

Capital Fund Spent	217,491,299.43	162,820,057
Government Grant Capital Spent	44,935,756.19	50,141,482
	262,427,055.62	**212,961,539**

Capital Fund Unspent

Capital Fund Unspent	1,924,562.94	710,970
Government Grant Capital Unspent	11,669,798.81	5,743,353
	13,594,361.75	**6,454,323**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 13

OTHER INCOME

	SLRs 2013	SLRs 2012
Foreign & Local Grants (NOTE 13A)	9,271,537.82	16,550,542
Donation	-	268,488
Sale of Books	103,870.64	13,172
Sundry Income	221,531.43	183,717
Interest Received	308,680.24	177,350
Foreign Currency Exchange Gaining	184,186.82	121,290
Income - Hiring Auditorium	50,000.00	20,000
Rent Income -NRC	-	120,000
Income - Accomadation	681,209.51	532,531
	10,821,016.46	**17,987,090**

NOTE 13A

FOREIGN & LOCAL GRANTS INCOME

School Science Programme	377,066.96	153,906
NSF- RG/SCH/2012/02	36,318.27	-
RG/2012/NRB/03	743,811.34	-
Specified Research Grant Fund	-	1,487,539
Science Magazine	55,300.00	-
CCD Murunga	7,344.63	94,584
Copenhagen University	48,903.24	130,544
Water Quality	9,334.45	8,182
N.W.S.D.B Saitation-Kala Oya	-	108,009
Saitma University	3,400.32	48,949
Vidukirana	600,699.25	44,861
Annual Review	262,500.00	68,500
IFS Sweeden Grant	33,500.00	-
Sola - Asia	-	27,098
Vidatha	-	5,299
Symposium	3,750.00	-
University of Sydney	1,452,590.05	1,729,870
C.K.D. Wiyaba	108,268.57	270,148
RG/2011/BS/01	205,414.75	259,487
HETC Project	348,610.38	132,518
Anuradapura District- Water Tank	-	7,514,000
Water Purification - Jaffna	-	84,003
Rhizobium - Prof. Kulasooriya	1,138,781.88	440,724
Manaweli Irrigation- Prof. Kulasooriya	83,022.00	133,788
PV Workshop - Prof. L.Dissanayake	2,400.00	151,071
RG/2011/AG/09	252,334.80	497,669
RG/2012/SPR/02	-	614,099
RG/2012/BS/06 NSF - Prof. Kumar	587,080.00	75,587
Rhizobium Master Class - Prof. Kulasooriya	89,822.29	2,045,289
Tokyo Cement - Dr. Iqbal	82,754.00	106,521
NSF- RG/2012/AG/01 - Dr. Jayasinghe	745,531.52	318,297

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013		
RG/2011/BS/04	650,710.36	-
Dayata Kirula	68,894.72	-
Science Camp	11,600.00	-
Sample Analysis	112,883.00	-
NSF/ESA/01	374,060.33	-
Traning Programme	430,141.50	-
MTR Indian Grant	208,853.21	-
Short Course	11,540.00	-
Specified Research Grant Fund	124,316.00	-
	9,271,537.82	**16,550,542**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 14

EXPENDITURE FOR PERSONAL EMOLUMENTS

		SLRs 2013	SLRs 2012
Salaries	ppendix 01)	67,553,004.65	59,762,566
EPF	ppendix 01)	8,533,001.23	7,208,770
ETF	ppendix 01)	1,714,946.69	1,441,754
Temporary Staff Allowances		919,695.00	930,188
Overtime		983,193.75	850,050
		79,703,841.32	**70,193,328**

NOTE 15

TRAVELLING

Local	ppendix 01)	231,561.00	245,139
Foreign	ppendix 01)	545,911.40	269,291
		777,472.40	**514,430**

NOTE 16

EXPENDITURE FOR SUPPLIERS & CONSUMABLES

Stationery &	ppendix 01)	530,818.25	487,490
Fuel and Lubricants		2,084,471.77	1,797,095
Chemical &	ppendix 01)	2,161,264.97	3,755,619
Consumabl	ppendix 01)	5,016,128.63	3,166,117
		9,792,683.62	**9,206,321**

NOTE 17

EXPENDITURE FOR MAINTENANCE

Building	ppendix 01)	483,556.38	485,091
Equipment	ppendix 01)	1,569,239.65	1,967,964
Vehicle		874,779.16	875,011
		2,927,575.19	**3,328,066**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 18

EXPENDITURE FOR CONTRACTUAL SERVICES

	SLRs 2013	SLRs 2012
Transport	540,976.36	1,071,259
Telecommunication	710,615.81	688,841
Postage	116,740.00	104,363
Electricity	6,873,744.45	6,083,593
Water	1,432,207.42	922,731
Garden Maintenance	446,497.25	368,103
Janitorial Services	674,932.35	651,840
Security Services	1,963,031.64	1,962,536
Catering Services	300,000.00	300,000
Internet Service	1,307,712.59	1,419,417
	14,366,457.87	**13,572,683**

NOTE 19

OTHER EXPENDITURE

Advertisement	441,056.00	323,120
Arboretum Expenses	180,000.00	200,000
Audit Fees	200,000.00	130,000
Auditorium And Room Maintenance	94,777.39	170,896
Bank Charges	28,554.99	38,369
Entertainment	6,000.00	5,250
Grant Expenses (Note 19A)	9,271,537.82	16,550,542
Gratuity	2,085,928.99	1,016,588
Staff Insurance	420,025.88	408,899
Insurance - Building	344,057.16	344,057
Insurance Motor Vehicle & License Fee	594,375.04	364,168
Journal Periodicals & Subscription	327,317.36	235,931
Membership Fees	588,268.21	723,970
Miscellaneous	461,703.27	646,281
Printing / Photocopy	82,601.00	45,924
Publication - Donation	710.40	7,301
Research Council Meeting Expenses	33,462.00	17,949
Welfare	1,190,003.52	1,005,223
Legal Expenses	408,600.00	-
	16,758,979.03	**22,234,468**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 19A

GRANT EXPENSES

	SLRs 2013	SLRs 2012
School Science Programme	377,066.96	153,906
NSF- RG/SCH/2012/02	36,318.27	-
RG/2012/NRB/03	743,811.34	-
Specified Research Grant Fund	-	1,487,539
Science Magazine	55,300.00	-
CCD Murunga	7,344.63	94,584
Copenhagen University	48,903.24	130,544
Water Quality	9,334.45	8,182
N.W.S.D.B Saitation-Kala Oya	-	108,009
Saitma University	3,400.32	48,949
Vidukirana	600,699.25	44,861
Annual Review	262,500.00	68,500
IFS Sweeden Grant	33,500.00	-
Sola - Asia	-	27,098
Vidatha	-	5,299
Symposium	3,750.00	-
University of Sydney	1,452,590.05	1,729,870
C.K.D. Wiyaba	108,268.57	270,148
RG/2011/BS/01	205,414.75	259,487
HETC Project	348,610.38	132,518
Anuradapura District- Water Tank	-	7,514,000
Water Purification - Jaffna	-	84,003
Rhizobium - Prof. Kulasooriya	1,138,781.88	440,724
Manaweli Irrigation- Prof. Kulasooriya	83,022.00	133,788
PV Workshop - Prof. L.Dissanayake	2,400.00	151,071
RG/2011/AG/09	252,334.80	497,669
RG/2012/SPR/02	-	614,099
RG/2012/BS/06 NSF - Prof. Kumar	587,080.00	75,587
Rhizobium Master Class - Prof. Kulasooriya	89,822.29	2,045,289
Tokyo Cement - Dr. Iqbal	82,754.00	106,521
NSF- RG/2012/AG/01 - Dr. Jayasinghe	745,531.52	318,297
RG/2011/BS/04	650,710.36	-
Dayata Kirula	68,894.72	-
Science Camp	11,600.00	-
Sample Analysis	112,883.00	-
NSF/ESA/01	374,060.33	-
Traning Programme	430,141.50	-
MTR Indian Grant	208,853.21	-
Short Course	11,540.00	-
Specified Research Grant Fund	124,316.00	-
	9,271,537.82	**16,550,542.00**

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31.12.2013

NOTE 20

PRIOR YEAR ADJUSTMENT

	SLRs 2013	SLRs 2012
Credit		
Stationary Stock	-	3,033
Reimbursement Travelling Expense-NSF	-	400
Reimbursement Fuel Expense-NSF	4,559.54	740
Reimbursement Over time Expense-NSF	-	3,900
Reimbursement Travelling Expense-NRC	-	1,200
Reimbursement Fuel Expense-NRC	-	11,730
Reimbursement Over time Expense-NRC	-	3,011
Accommodation	-	2,500
Dialog telecom	-	1,000
Sri lanka insurance	-	18,221
Salary	47,879.65	-
Membership	27,912.52	-
1% Administration Expenses	36,325.32	-
Major Vehicle Repair	150,250.00	-
	266,927.03	45,735
Debit		
Foreign Travel	-	56,692
Tempory salary	-	22,811
Visiting salary	-	7,565
Dialog Bill	809.92	-
Depreciation	1,577,004.39	-
Coconut Research	-	-
Chemical & Glassware	7,670.12	-
Membership	6,661.04	-
Salary	610,877.69	-
EPF & ETF	460,131.08	-
Telephone	-	15,184
	2,663,154.24	102,252
	(2,396,227.21)	**(56,517)**

APPENDIX 01

PROJECT RECURRANT EXPENDITURE

PROJECT	CHEMICAL & GLASSWARE, CONSUMABLE	EQUIPMENT MAINTANANCE	BUILDING MAINTANANCE	FOREIGHN TRAVELLING	STATIONARY	TRANSPORT	LOCAL TRAVELLING	SALARIES, EPF,ETF
PLANT BIOTECHNOLOGY	312,056	41,839	67,335	55,914	12,560	8,340	43,925.00	4,364,684
THEORETICAL & COMPUTATIONAL SCIENCE	596,040	11,699	9,728	-	5,635	-	2,500.00	4,537,983
NATURAL PRODUCT CHEMISTRY	893,373	27,467	4,188	46,842	12,068	6,135	5,000.00	7,361,822
CELL BIOLOGY	1,073,713	38,055	9,835	59,960	13,796	2,100	13,050.00	3,360,251
SOLIDE STATE CHEMISTRY	280,909	17,255	925	167,677	12,053	-	8,994.00	2,274,765
CONDENCE MATTER PHYSICS								1,093,860
PHOTOCHEMISTRY	416,417	60,468	4,783	62,000	12,936	-	2,600.00	4,525,796
ECOLOGY & ENVIRONMENTAL BIOLOGY	382,455	39,445	16,998	-	9,105	1,400	12,660.00	3,157,062
MICROBIAL BIOTECHNOLOGY UNIT								-
BIO FILMED BIO FERTILIZER	702,527	106,680	21,007	-	25,028	700	4,400	7,316,335
BIOFUELL	460,894	10,179	1,090	11,518	7,470		17,825	
GEOTHERMAL RESOURCE MAPPING	36,484	48,360	13,800	62,000	14,052	-	4,200	4,334,958
CHEMICAL & ENVIORONMENTAL MODELLING	354,038	30,012	39,331	-	10,531	-	2,400	2,859,882
ELECTRO CHEMICAL MATERIALS	285,208	14,456	6,341	-	9,041	-	1,400	1,945,026
FOOD SCIENCE NATURAL - I	1,216,681	200,316	-	80,000	8,121	-	1,000	2,833,216
FOOD SCIENCE NATURAL - II	12,301	8,550	652	-	942	-	1,400	1,005,595
ADMINISTRATION	154,298	914,459	287,543	-	377,480	522,301	110,207	26,809,718
TOTAL	**7,177,394**	**1,569,240**	**483,556**	**545,911**	**530,818**	**540,976**	**231,561**	**77,780,953**

AGE ANALYSIS OF DEBTORS & OTHER RECEIVABLES AS AT 31.12.2013

ADVANCES AND OTHER RECEIVABLES Rs : 135,426.39

	0 - 12 MONTHS Rs	1 - 2 YEARS Rs	2 - 3 YEARS Rs	3-4 YEARS Rs	4 - 5 YEARS Rs	OVER 5 YEARS Rs
P.K.D.Chathuranga	18,000.00	-	-	-	-	-
Silverstone ltd	47,500.00	-	-	-	-	-
I.F.S. E.P.F.1%	55,398.43	-	-	-	-	-
Accomadation	7,500.00	-	-	-	-	-
Ministry of Technology	7,027.96	-	-	-	-	-
	135,426.39	-	-	-	-	-

FESTIVAL ADVANCE Rs:45,000.00

	0 - 12 MONTHS Rs	1 - 2 YEARS Rs	2 - 3 YEARS Rs	3-4 YEARS Rs	4 - 5 YEARS Rs	OVER 5 YEARS Rs
	45,000.00	-	-	-	-	-
	45,000.00	-	-	-	-	-

ACCRUED EXPENSES Rs 1,907,445.69

	0 - 12 MONTHS Rs	1 - 2 YEARS Rs	2 - 3 YEARS Rs	3-4 YEARS Rs	4 - 5 YEARS Rs	OVER 5 YEARS Rs
Traveling & Subsistence	5,400.00	-	-	-	-	-
Government Audit Fees	200,000.00	102,592.00	-	-	-	-
Temporary Staff Salaries	85,930.00	-		-	-	-
Communication	46,270.90	-	-	-	-	-
Overtime IFS	90,477.61	-	-	-	-	-
Security Services	163,585.97	-	-	-	-	-
Welfare	93,934.00	-	-	-	-	-
General Upkeep - Janitorial	59,963.75	-	-	-	-	-
General Upkeep - Garden Mainte	39,292.25	-	-	-	-	-
General Upkeep - Catering	25,000.00	-	-	-	-	-
Water Charges	141,684.52	-	-	-	-	-
Internet	101,271.97	-	-	-	-	-
Visiting Salary-Prof. S.A. Kulasoc	36,444.55	-	-	-	-	-
Electricity	276,060.88	-	-	-	-	-
Stamp Duty	12,180.00	-	-	-	-	-
Grant Allowances	374,045.47	-	-	-	-	-
Transport	42,000.00	-	-	-	-	-
Overtime Grant	11,311.82	-	-	-	-	-
	1,804,853.69	**102,592.00**	-	-	-	-

AGE ANALYSIS OF DEBTORS & OTHER RECEIVABLES AS AT 31.12.2013

OTHER CREDITORS AND PAYABLE BALANCE AS AT 31.12.2013 Rs : 132,974.72

	0 - 12 MONTHS Rs	1 - 2 YEARS Rs	2 - 3 YEARS Rs	3-4 YEARS Rs	4 - 5 YEARS Rs	OVER 5 YEARS Rs
NRC Rent (Refundable Deposit)	-	-	-	-	-	90,000.00
Disposable Item (Refundable Dep	900.00	-	-	-	-	-
Inland Revenue tax	-	105.90	-	-	-	-
Malwatte Contractors	-	-	-	-	-	27,000.00
Sooner Scientific	-	-	-	14,968.82	-	-
	900.00	**105.90**	-	**14,968.82**	-	**117,000.00**

AGE ANALYSIS OF CREDITORS-SUPPLIERS AND SERVICES AS AT 31.12.2013 - Rs: 1,124,306.85						
	0 - 12 MONTHS Rs	1 - 2 YEARS Rs	2 - 3 YEARS Rs	3-4 YEARS Rs	4 - 5 YEARS Rs	OVER 5 YEARS Rs
Kandy Tyre Rebuilding Co. Ltd	75,552.40	-	-	-	-	-
T. Gamini	58,500.00	-	-	-	-	-
Analytical Instruments (Pvt) Ltd	296,725.00	-	-	-	-	-
Dr..R.Rathnayaka	11,519.10	-	-	-	-	-
Hemsons International (pte)Ltd	95,737.60	-	-	-	-	-
Haji M.K.M.Hassan & Sons	4,930.00	-	-	-	-	-
Organic Trading (pvt) Ltd	42,884.80	-	-	-	-	-
W.G.Jayasekara	3,491.30	-	-	-	-	-
R.D.W.C.Rajapaksha	230.00	-	-	-	-	-
R.G.K.Kumara	5,000.00	-	-	-	-	-
Dr.M.Vithanage	3,735.00	-	-	-	-	-
Dr.Benjamin	800.00	-	-	-	-	-
K.I.K.Samarakoon	920.00	-	-	-	-	-
D.G.Gunathilaka	545.00	-	-	-	-	-
Namal Athukorala	2,340.00	-	-	-	-	-
S.B.Fright Services	40,582.00	-	-	-	-	-
R.K.C.Karunarathna	1,582.25	-	-	-	-	-
Kundasala Auto Services	19,838.00	-	-	-	-	-
ACE International Care	23,096.58	-	-	-	-	-
C.A.Thotawatta	26,982.90	-	-	-	-	-
Prof.L.Dissanayaka	19,347.00	-	-	-	-	-
S.L.Jayaratna	19,347.00	-	-	-	-	-
O.S.Perera	38,827.48	-	-	-	-	-
Dr.R.Liyanage	41,172.52	-	-	-	-	-
Dr.M.C.M.Iqbal	56,153.60	-	-	-	-	-
Prof.U.L.B.Jayasingha	24,338.20	-	-	-	-	-
Jeewa Kasthuri	3,500.00	-	-	-	-	-
Ampitiya Auto Care	16,860.00	-	-	-	-	-
M.A.G.Somananda	400.00	-	-	-	-	-
L.Wenkadasamy	2,487.00	-	-	-	-	-
H.M.Saman Priyadeva	1,600.00	-	-	-	-	-
Dinapala (pvt) Ltd	36,250.00	-	-	-	-	-
R.S.K.Gunawardana	400.00	-	-	-	-	-
Green Park Holding	22,700.00	-	-	-	-	-
Royal Garden Hotel	86,285.00	-	-	-	-	-
Siri Ramya Hotel & Bakers	30,000.00	-	-	-	-	-
Solvkem Trading Company	5,100.00	-	-	-	-	-
Dr.Athula Wijesingha	4,547.12	-	-	-	-	-
		-	-	-	-	-
	1,124,306.85	-	-	-	-	-

	TRIAL BALANCE AS 31.12.2013		
NO		**DEBIT**	**CREDIT**
F/A/1	AIR CONDITIONER	4,796,607.80	-
F/A/2	BUILDING	29,728,586.91	-
F/A/3	COMPUTER & PRINTERS	17,764,705.47	-
F/A/4	COMMUNICATION EQUIPMENT	871,185.42	-
F/A/5	FURNITURE & FITTINGS	3,308,486.74	-
F/A/6	IMPROVEMENTS TO BUILDING	-	-
F/A/7	LAND	28,622,151.00	-
F/A/8	LABORATORY EQUIPMENT	219,027,204.63	-
F/A/9	LIBRARY BOOKS	12,722,628.01	-
F/A/10	MOTOR VEHICLE	20,574,263.55	-
F/A/11	MACHINERY TOOLS & IMPLEMENTS	764,994.28	-
F/A/12	OFFICE & MISCELLANEOUS EQUIPMENT	18,943,869.06	-
F/A/13	REFRIGERATORS	1,682,480.38	-
F/A/14	SPORT ITEMS	13,480.00	-
F/A/15	MOTOR VEHICLE OVERHALL	-	-
F/A/16	KITCHEN EQUIPMENT	-	-
F/A/17	TRAINING CAPACITY	823,697.40	-
O/F/A/1	EMPLOYEE PROVIDENT FUND INVESTMENT	40,150,001.93	-
O/F/A/2	DISPOSAL OF FIXED ASSETS	24,915,351.37	-
O/F/A/3	MODEL OF LAND	37,500.00	-
O/F/A/4	INVESTMENT OF CONSUMPTION LOAN	192,962.16	-
O/F/A/5	GEOTERMAL MAPPING REPORT	1,097,477.65	-
O/F/A/6	NEW BUILDING - WORKING PROGRES	62,920,000.00	-
C/A/1	BUILDING MAINTENANCE STOCK	234,090.29	-
C/A/2	CHEMICAL GLASSWARE AND LAB WARE STOCK	1,373,078.08	-
C/A/3	CONSIGNED STOCK	17,405.84	-
C/A/4	STATIONERY STOCK	148,069.47	-
C/A/5	SUNDRY STOCK	115,491.98	-
C/A/6	PUBLICATION STOCK	154,117.20	-
C/A/10	INSURANCE CLAIM RECEIVABLE(JANASHAKTHI)	-	(0.00)
C/A/11	ADVANCE TO SUPPLIES & OTHERS	65,500.00	-
C/A/12	FOREIGN PAYMENTS ON ADVANCE	2,948,841.49	-
C/A/13	LETTER OF CREDIT MARGIN	1,998,158.00	-
C/A/14	FESTIVAL ADVANCE	45,000.00	-
C/A/15	SPECIAL ADVANCE	-	-
C/A/16	SALARY ADVANCE	-	-
C/A/18	REFUNDABLE DEPOSIT	417,100.00	-
C/A/19	PREPAYMENT	662,050.47	-
C/A/20	OTHER RECEIVABLE ACCOUNT	69,926.39	-
C/A/21	INTEREST RECEIVABLE FOR FIXED DEPOSIT	4,452,481.52	-
C/A/22	NRC BUILDING DEPOSIT	-	90,000.00
C/A/23	REFUNDABLE DEPOSIT FOR DISPOSABLE ITEMS	-	900.00
C/A/24	REFUNDABLE BENCH FEES	-	-
C/A/26	SOONER SCIENTIFIC	-	14,968.82
C/A/36	HYDRAULIC JACK	4,000.00	-
C/A/38	BOOK RACK NATU . PRODUCT	-	-
C/A/39	STAND ST, GEOLOGY	4,960.00	-
C/A/40	FESTIVAL ADVANCE INVESTMENT ACCOUNT	255,000.00	-
C/A/41	DIRECTOR BUILDING DEPARTMENT - ADVANCE	1,782,831.13	-

C/A/42	MAPPING	-	-
C/A/43	CONTRIBUTION FORM WELFARE	129,668.89	
C/A/45	NEW SCIENCE BUILDING	-	-
C/A/46	ADVANCE FOR CART (LIBARAY)	-	-
C/A/47	ADVANCE FOR RACK (ADM)	-	-
C/A/48	ADVANCE FOR STAND (DIRECTORS OFF.)	-	-
L/1	ACCRUED EXPENSES	-	1,907,445.69
L/2	CREDITORS	-	1,124,306.85
L/3	CAPITAL FUND SPENT	-	217,491,299.43
L/4	CAPITAL FUND UNSPENT	-	1,924,562.94
L/5	E.P.F. PAYABLE	-	-
L/6	E.T.F. PAYABLE	-	-
L/8	I.F.S.PROVIDENT FUND	-	54,289,790.55
L/10	INSTITUTE FUND	14,841,859.00	-
L/12	PROVISION FOR GRATUITY	-	15,640,908.99
L/13	PROVISION FOR DEPRECIATION	-	103,280,731.81
L/14	PRESIDENT FUND CAPITAL SPENT-SUPPLEMENTARY	-	7,078,501.15
L15	RENT PAYBLE	-	-
L/19	OTHER PAYABLE ACCOUNTS	-	-
L/20	RETENTION MONEY PAYABLE	-	-
L/21	RETIRED MEMBERS FUND ACCOUNT	-	2,153,269.66
L/22	CAPITAL EXPENDITURE SPECIFIED FUNDS & DONAT	-	2,558,294.68
L/23	SCHOOL SCIENCE PROGRAMME	-	12,257.04
L/24	PAYABLE OF 10% to WELFARE ASSOCIATION	-	129,668.89
L/25	BUILDING CONTRACTORS	-	27,000.00
L/26	FESTIVAL ADVANCE - FUND ACCOUNT	-	255,000.00
L/28	CONSUMPTION FUND	-	192,962.16
L/36	SPECIFIED RESEARCH GRAND FUND	-	1,663,184.39
L/38	EEB WATER ANALYZED	-	-
L/42	BES GRANT	-	62,412.22
L/44	GOV. TAX	-	105.90
L/45	DEP OF INLAND REVENUE	-	-
L/46	RG/2006/AASR/04 DR GAMINI	-	54,505.83
L/48	RG/2006/EB/08	-	35,522.39
L/53	WORK SHOP(TEACHERS CHILDREN'S)	-	-
L/55	BIOASSAYS	-	49,442.83
L/56	SCIENCE MAGAZINE	-	174,705.75
L/57	COLLABORATIVE	-	-
L/58	SAITAMA UNIVERSITY	-	-
L/60	N.W.S.D.B. SAITATION	-	-
L/61	DR. VITHANA COPENHAGEN	-	-
L/65	VIDU KIRANA	-	144,992.15
L/66	ANNUAL REVIEW		10,000.00
L/67	NAWALA OPEN UNIVERSITY	-	-
L/68	OPEN UNIVERSITY SRI LANKA	-	-
L/69	UNIVERSITY OF KELANIYA	-	-
L/70	SOLA ASIA	-	310,912.75
L/71	VIDATHA	-	-
L/72	SYMPOSIUM	-	306,195.07
L/73	UNIVERSITY OF SYDNEY	-	475,742.20
L/75	C.K.D	-	-
L/76	RG/2011BS/01 DR NADEESHANI	-	116,117.98

C/A/42	MAPPING	-	-
C/A/43	CONTRIBUTION FORM WELFARE	129,668.89	
C/A/45	NEW SCIENCE BUILDING	-	-
C/A/46	ADVANCE FOR CART (LIBARAY)	-	-
C/A/47	ADVANCE FOR RACK (ADM)	-	-
C/A/48	ADVANCE FOR STAND (DIRECTORS OFF.)	-	-
L/1	ACCRUED EXPENSES	-	1,907,445.69
L/2	CREDITORS	-	1,124,306.85
L/3	CAPITAL FUND SPENT	-	217,491,299.43
L/4	CAPITAL FUND UNSPENT	-	1,924,562.94
L/5	E.P.F. PAYABLE	-	-
L/6	E.T.F. PAYABLE	-	-
L/8	I.F.S.PROVIDENT FUND	-	54,289,790.55
L/10	INSTITUTE FUND	14,841,859.00	-
L/12	PROVISION FOR GRATUITY	-	15,640,908.99
L/13	PROVISION FOR DEPRECIATION	-	103,280,731.81
L/14	PRESIDENT FUND CAPITAL SPENT-SUPPLEMENTARY	-	7,078,501.15
L15	RENT PAYBLE	-	-
L/19	OTHER PAYABLE ACCOUNTS	-	-
L/20	RETENTION MONEY PAYABLE	-	-
L/21	RETIRED MEMBERS FUND ACCOUNT	-	2,153,269.66
L/22	CAPITAL EXPENDITURE SPECIFIED FUNDS & DONATION	-	2,558,294.68
L/23	SCHOOL SCIENCE PROGRAMME	-	12,257.04
L/24	PAYABLE OF 10% to WELFARE ASSOCIATION	-	129,668.89
L/25	BUILDING CONTRACTORS	-	27,000.00
L/26	FESTIVAL ADVANCE - FUND ACCOUNT	-	255,000.00
L/28	CONSUMPTION FUND	-	192,962.16
L/36	SPECIFIED RESEARCH GRAND FUND	-	1,663,184.39
L/38	EEB WATER ANALYZED	-	-
L/42	BES GRANT	-	62,412.22
L/44	GOV. TAX	-	105.90
L/45	DEP OF INLAND REVENUE	-	-
L/46	RG/2006/AASR/04 DR GAMINI	-	54,505.83
L/48	RG/2006/EB/08	-	35,522.39
L/53	WORK SHOP(TEACHERS CHILDREN'S)	-	-
L/55	BIOASSAYS	-	49,442.83
L/56	SCIENCE MAGAZINE	-	174,705.75
L/57	COLLABORATIVE	-	-
L/58	SAITAMA UNIVERSITY	-	-
L/60	N.W.S.D.B. SAITATION	-	-
L/61	DR. VITHANA COPENHAGEN	-	-
L/65	VIDU KIRANA	-	144,992.15
L/66	ANNUAL REVIEW		10,000.00
L/67	NAWALA OPEN UNIVERSITY	-	-
L/68	OPEN UNIVERSITY SRI LANKA	-	-
L/69	UNIVERSITY OF KELANIYA	-	-
L/70	SOLA ASIA	-	310,912.75
L/71	VIDATHA	-	-
L/72	SYMPOSIUM	-	306,195.07
L/73	UNIVERSITY OF SYDNEY	-	475,742.20
L/75	C.K.D	-	-
L/76	RG/2011BS/01 DR NADEESHANI	-	116,117.98

L/78	HETC PROJECT	-	126,689.79
L/79	ANURADAPURA DISTRIC TANK	-	2,400,000.00
L/81	RG/2011/AG/09	-	91,557.02
L/82	IFS SWEEDEN	-	391,436.05
L/83	RHIZOBIUM	-	1,721,986.32
L/84	RG/2012/AG/01	-	323,848.81
L/85	MAHAWELI IRRIGATION	-	-
L/86	PV WORK SHOP	-	40,031.78
L/87	RG/2012/EQ/03	-	-
L/89	RG/2012/BS/06	-	364,482.57
L/90	MASTER CLASS	-	-
L/91	NSF/SCH/2012/02	-	263,681.73
L/92	RG/2012/NRB/03	-	24,996.96
L/93	RG/2012/BS/04	-	194,289.64
L/94	WATER QUALITY	-	39,356.32
L/95	TOKYO CEMENT COMPANY		-
L/96	REVALUVATION RESERVE	-	122,463,619.32
L/97	MTR DAYATA KIRULA	-	13,825.28
L/98	SCIENCE CAMP	-	-
L/99	SAMPLE ANALIZED PROF: GAMINI	-	59,117.00
L/100	NSF/ESA/01	-	977,439.67
L/101	RG/2012/EQ/07	-	-
L/102	SPECTRA INDUSTRIES	-	290,000.00
l/104	MTR (INDIAN)	-	791,146.79
L/103	TRANNING PROGRAM	-	19,858.50
L/105	SHORTCOURSE	-	-
L/106	TOKYO CEMENT - COTTAGE	-	520,245.00
L/107	NSF - VIDU NANA DASUNA(VND)	-	300,000.00
L/108	ANNUAL REVIEW - DR. KUMARI	-	-
L/109	TOKYO CEMENT SSP	-	-
I/1	FOREIGN CURRENCY EXCHANGE GAINING	-	184,186.82
I/2	GOVERNMENT GRANT RECURRENT	-	117,068,000.00
I/3	GOVERNMENT GRANT CAPITAL -SPENT -RS.44,935,756.19	-	56,605,555.00
	-UN SPENT RS.11,669,798.81	-	-
I/4	ACCOMADATION INCOME	-	681,209.51
I/5	HIRING AUDITORIUM	-	50,000.00
I/6	INTEREST RECEIVED	-	308,680.24
I/7	SALE OF BOOKS	-	103,870.64
I/8	SUNDRY INCOME	-	221,531.43
I/10	DONATION	-	-
I/13	SALE OF DISPOSABLE ITEM	-	-
I/16	FOREIGN & LOCAL GRAND FUND INCOME	-	9,271,537.82
I/17	NRC RENT	-	-
I/18	SALE OF VEHICAL	-	-
E/1	ADVERTISEMENT	441,056.00	-
E/2	AUDIT FEES	200,000.00	-
E/3	AUDITORIUM AND ROOMS MAINTENANCE EXPENSES	94,777.39	-
E/4	BUILDING INSURANCE	344,057.16	-
E/5	BANK CHARGES	28,554.99	-
E/6	COMMUNICATION	710,615.81	-
E/7	CLEARANCE	47,679.79	-
E/8	DEFENSE LEVY AND GST	250,182.46	-
E/9	DAMBULLA ARBORETUM	180,000.00	-

E/10	ELECTRICITY	6,873,744.45	-
E/11	FUEL	2,084,471.77	-
E/12	GENERAL UP KEEP-JANITORIAL SERVICE	674,932.35	-
E/13	GENERAL UPKEEP-GARDEN MAINTENANCE	446,497.25	-
E/14	GENERAL UPKEEP-CATERING SERVICE	300,000.00	-
E/15	GRATUITY	2,085,928.99	-
E/16	MAINTENANCE OF MOTOR VEHICLES	874,779.16	-
E/17	MOTOR VEHICLE INSURANCE	529,335.71	-
E/18	MOTOR VEHICLE LICENSE	65,039.33	-
E/19	MAINTENANCE OF BUILDING	483,556.38	-
E/20	MAINTENANCE OF EQUIPMENT	1,569,239.65	-
E/21	OVERTIME	983,193.75	-
E/22	POSTAGE	116,740.00	-
E/23	PRIOR YEAR ADJUSTMENT	2,396,227.21	-
E/24	RESEARCH COUNCIL MEETING EXPENSES	33,462.00	-
E/25	SECURITY	1,963,031.64	-
E/26	STAFF TRANSPORT	540,976.36	-
E/28	SUBSCRIPTION PERIODICALS & JOURNALS	327,317.36	-
E/29	MEMBERSHIP FEES	588,268.21	-
E/30	STAFF INSURANCE	420,025.88	-
E/31	TRAVELLING & SUBSISTENCE	231,561.00	-
E/32	WELFARE	1,190,003.52	-
E/33	WATER	1,432,207.42	-
E/34	SALARY	67,553,004.65	-
E/35	E.P.F. 15%	8,533,001.23	-
E/36	E.T.F. 3%	1,714,946.69	-
E/37	STATIONARY USED	530,818.25	-
E/38	CHEMICAL GLASSWARE AND LABWARE USED	2,161,264.97	-
E/39	CONSUMABLE	5,016,128.63	-
E/40	PRINTING	82,601.00	-
E/41	LEGAL EXPENSES	408,600.00	-
E/43	ENTERTAINMENT ALLOWANCE	6,000.00	-
E/45	DEPRECIATION	27,759,753.84	-
E/47	TEMPORARY STAFF ALLOWANCE	919,695.00	-
E/49	MISCELLANEOUS	461,703.27	-
E/50	INTERNET	1,307,712.59	-
E/53	FOREIGN &LOCAL GRAND EXPENDITURE	9,271,537.82	-
E/54	PUBLICATION DONATION	710.40	-
E/56	TRAVELLING FOREIGN	545,911.40	-
E/57	ROOM EXPENDITURE	-	-
E/58	DESPOSAL YEAR 2013	1,570,623.42	-
O/C/B/1	NATIONAL SAVINGS BANK. A/C NO1-0015-01-02989	9,416,248.22	-
O/C/B/2	RESEARCH FUND N.S.B.1-0015-01-03152	60,724.39	-
O/C/B/3	PETTY CASH CONTROL ACCOUNT	-	-
O/C/B/4	PETTY CASH IMPREST	6,000.00	-
O/C/B/5	STAMP IMPREST	500.00	-
O/C/B/6	PROVIDENT FUND CURRENT ACCOUNT B.O.C.32794	2,414,937.85	-
O/C/B/8	COLOMBO OFFICE	-	-
	N.S.B A/C NO.100151091808	192,962.16	-
O/C/B/11	STAFF CONSUMPTION LOAN RECEIVABLE A/C	3,948,038.00	-
	BANK OF CEYLON 32779	14,019,101.96	-
	BANK OF CEYLON 32795	16,627,197.39	-
	CASH	-	-
	SFCA/KN/USD/01	5,773,438.50	-
		727,487,888.13	**727,487,888.13**

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கணக்காய்வாளர் தலைமை அதிபதி திணைக்களம்
AUDITOR GENERAL'S DEPARTMENT

මගේ අංකය / எனது இல. / My No. CL1/KD/J/IFS/1/13/12 | ඔබේ අංකය / உமது இல. / Your No. | දිනය / திகதி / Date 26 January 2015

Director
Institute of Fundamental Studies of Sri Lanka

Report of the Auditor General on the Financial Statements of the Institute of Fundamental Studies of Sri Lanka for the year ended 31 December 2013 in terms of Section 14(2)(c) of the Finance Act, No. 38 of 1971

The audit of financial statements of the Institute of Fundamental Studies of Sri Lanka for the year ended 31 December 2013 comprising the statement of financial position as at 31 December 2013 and the statement of financial performance, statement of changes in equity and cash flow statement for the year then ended and a summary of significant accounting policies and other explanatory information, was carried out under my direction in pursuance of provisions in Article 154 (1) of the Constitution of the Democratic Socialist Republic of Sri Lanka read in conjunction with Section 13(1) of the Finance Act, No. 38 of 1971 and Section 36(4) of the Institute of Fundamental Studies of Sri Lanka Act, No. 55 of 1981. My comments and observations which I consider should be published with the Annual Report of the Institute in terms of Section 14(2)(c) of the Finance Act appear in this report. A detailed report in terms of Section 13(7)(a) of the Finance Act was furnished to the Chairman of the Institute on 17 June 2014.

1.2 Management's Responsibility for The Financial Statements

Management is responsible for the preparation and fair presentation of these financial statements in accordance with Sri Lanka Public Sector Accounting Standards and for such internal control as the management determines is necessary to enable the preparation of financial statements that are free from material misstatements whether due to fraud or error.

1:3 Auditor's Responsibility

My responsibility is to express an opinion on these financial statements based on my audit. I conducted my audit in accordance with Sri Lanka Auditing Standards consistent with International Standards of Supreme Audit Institutions (ISSAI 1000 – 1810). Those Standards require that I comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatements.

අංක 306/72, පොල්දූව පාර, බත්තරමුල්ල, ශ්‍රී ලංකාව. . - இல. 306/72, பொல்துவ வீதி, பத்தரமுல்லை, இலங்கை. - No. 306/72, Polduwa Road, Battaramulla, Sri Lanka
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An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgments, including the assessment of the risks of material misstatements of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Institute's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Institute's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by management, as well as evaluating the overall presentation of financial statements. Sub-sections (3) and (4) of Section 13 of the Finance Act, No. 38 of 1971 give discretionary powers to the Auditor General to determine the scope and extent of the audit.

I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my audit opinion.

1:4 Basis for Qualified Opinion

My opinion is qualified based on the matters described in paragraph 2.2 of this report.

2. Financial Statements

2.1 Qualified Opinion

In my of opinion, except for the effects of the matters described in paragraph 2.2 of this report the financial statements give a true and fair view of the financial position of the Institute of Fundamental Studies of Sri Lanka as at 31 December 2013 and its financial performance and cash flows for the year then ended in accordance with Sri Lanka Public Sector Accounting Standards.

2:2 Comments on Financial Statements

2:2:1 Sri Lanka Public Sector Accounting Standards

Even though prior year adjustments amounting to Rs.2,396,227 should be adjusted to the opening balance in terms of Sri Lanka Public Sector Accounting Standard No. 3, that had been adjusted to the operating results for the year under review, thus resulting in the overstatement of deficit for the year.

2.2:2 Accounting Deficiencies

The following observations are made.

(a) Two vans received as Government grants had been adjusted to the Fund of the Institute without being considered as a Government grant. Instead of obtaining a recognized assessment in accounting for the value of those, the assessed value of Rs.15,200,000 for insurance purposes had been used.

(b) Out of the laboratory equipment and furniture valued at Rs.26,624,391 brought forward in the preceding year under current assets with the intention of elimination from the Institute, item of assets valued at Rs.24,915,351 had been shown under current assets even in the year under review without being eliminated.

(c) Travelling expenses totalling Rs.57,848 payable to 3 officers of the Institute had been shown under supplies and services creditors instead of being shown under accrued expenses.

(d) Assets disposed of in the preceding years and assets confirmed as physically not available according to the Reports of Boards of Survey valued at Rs.658,020 continued to be shown as current assets in the financial statements.

2:2:3 Unreconciled Control Accounts

A decrease of Rs.314,639 was observed between the balances of 07 items of account according to subsidiary records and the ledger.

2:2:4 Accounts Receivable and Payable

The following observations are made.

(a) Action had not been taken even up to the end of the year under review for the settlement of 03 creditors balances payable amounting to Rs.131,968 existing over a period exceeding 05 years.

(b) Even though foreign advances amounting to Rs.105,851 had been granted to a private institution of supply services the relevant goods had not been supplied to the Institute even by the last day of the year under review.

(c) Confirmation of balances relating to 17 supply and service creditors balances valued at Rs.825,751 had not been received.

2.3 Non-compliance with Laws, Rules Regulations and Management Decisions

The following non-compliances were observed.

	Reference to Laws, Rules, Regulations, etc.	Non-compliance
(a)	Public Finance Circular No. 438 of 13 November 2009.	No action whatsoever had not been taken over on unused assets valued at Rs.2,994,823 identified by the Board of Survey for the year 2013.
(b)	No. RD/PAYE/REG/01 of 07 March 2011 of the Commissioner General of Inland Revenue and Budget Proposal 2011.	i. Pay As You Earn Tax amounting to Rs.212,884 for the year 2013 had been under-recovered from 19 Members of the teaching staff of the Institute. ii. Pay As You Earn Tax amounting to Rs.14,373 recovered on arrears of salary had not been remitted to the Commissioner General of Inland within the specified period.
(c)	Employees' Provident Fund Act, No. 15 of 1958 and the Letter No. PRA/EST/11 dated 24 August 2001 of the Commissioner General of Labour.	As study allowance is not interpreted as a cost of living allowance, that allowance should not be made applicable for contributions to the Employees' Provident Fund, the Pension Fund and the Employees' Trust Fund. But, the total sums paid contrary to the above instructions in respect of the teaching staff of the Institute to the Funds referred to above amounted to Rs.1,002,418.
(d)	Financial Regulations of the Democratic Socialist Republic of Sri Lanka Financial Regulation 110	Even though there were 04 accidents to motor vehicles in the years 2012 and 2013 a Register of Losses and Damage had not been maintained to record those.
(e)	Treasury Circular No. 842 of 19 December 1978.	A Register of Fixed Assets had not been maintained in terms of the Circular.

2:4 Transactions not Supported by Adequate Authority

The following observations are made.

(a) According to the circular No. 26/2010 dated 31 December 2010 of the Secretary to the Ministry of Public Administration and Home Affairs, no recruitment on temporary, casual, substitute, contract or relief bases to the posts in the Public Service without the prior approval of the Department of Management Services of the General Treasury. But salaries totalling Rs.919,695 had been paid in the year under review to 09 officers recruited contrary to that ruling.

(b) Thirteen Journals valued at Rs.2,285,906 furnished to audit had not been approved.

3. Financial Review

3:1 Financial Results

According to the financial statements presented, the deficit for the year ended 31 December 2013 amounted to Rs.28,164,597 as compared with the corresponding deficit of Rs.24,050,040 for the preceding year. As such the financial results for the year under review as compared with the preceding year indicted a deterioration of Rs.4,114,557.

3.2 Analytical Financial Review

The deficit as compared with the preceding year had increased by Rs.4,114,557 mainly due to the increase of the loss from the sale of fixed assets in the year under review by a um of Rs.1,570,623, the prior year adjustments by a sum of Rs.2,396,227 and the operating expenses by a sum of Rs.6,253,235.

4. Operating Review

4.1 Management Inefficiencies

The following observations are made.

(a) Two hundred and three books obtained from the library of the Institute by 30 officers during the years 1998 to 2012 had not returned despite the elapse of periods ranging from 02 to 15 years.

(b) It was observed in audit that 17 books not related to researches/ tests had been retained by 08 officers over periods ranging from 01 year to 10 years.

4:2 Operating Inefficiencies

The following observations are made.

(a) According to Section 5.2.2 of the Circular No. PED/12 dated 02 June 2003 of the Director General of Public Enterprises a feasibility study should be carried out for payments exceeding Rs.500,000. But 8 water purification units costing Rs.9,144,000 had been constructed during the years 2011 and 2012 without carrying out such feasibility study. Out of that 06 water purification units constructed at a cost of Rs.6,013,702 had become inoperative before the elapse of one year.

(b) (i) In terms of clause 16 of the agreement on the maintenance of the canteen of the Institute of Fundamental Studies of Sri Lanka, accommodation facilities for the manager and the employees of the canteen and stones facilities for keeping goods had been supplied. Instead of recovering a rent for that by the Institute in terms of clause 06 of the agreement, payments amounting to Rs.300,000 at the rate of Rs.25,000 per month had been made to the contractor during the year under review. The Institute had paid a sum of Rs.1,190,003 to the contractor in the year under review for the supply of tea to the officers.

(ii) Even though the contractor should supply an insurance cover of Rs.100,000 in terms of Clause 17 of the agreement for the use of equipment belonging to the Institute, such insurance cover had not been obtained from the contractor even by 31 December 2013.

4:3 Idle and Underutilized Assets

The following observations are made.

(a) Thirty Seven items of fixed assets valued at Rs.1,312,752 had been idling due to the failure to repair and use those or for taking any other course of action. In addition, no course of action whatsoever had been taken on 04 items of broken down goods valued at Rs.8,000.

(b) An examination of the stores of chemical stocks and the stock verification reports as at 31 December 2013 revealed that 86 items of stocks valued at Rs.548,555 had been non-moving stocks over a long period. Out of that 17 items valued at Rs.220,625 had been stored in deep freezers. No course of action on these items had been taken up to 31 December 2013.

(c) Sixty seven items of slow moving stocks valued at Rs.334,403 had been kept in the stores.

(d) Out of the 10 water purification units that should have been installed under the 2012 "Deyata Kirula National Development Programme Water Purification Project and action had not been taken to construct 02 water purification units even by 31 December 2013. It was observed that a sum of Rs.2,341,472 allocated for that purpose had been idling in the Bank Current Account over a period of 02 years and 06 months.

4:4 Transactions of Contentious Nature

The following observations are made.

(a) An overpayment of Rs.415,794 had been made due to the confirmation of appointment in the post of Assistant Accountant, granting promotion and payment of salary by placing on incorrect salary steps contrary to the Scheme of Recruitment.

(b) The officer functioning as the Secretary of the Research Council and the Board of Management had been paid Rs.1,500 and Rs.2,000 per meeting respectively. The officer recruited for the post of Driver had been paid Rs.2,000 per month in addition to the salary for office work. The total payments made in the year under review amounting to Rs.20,000.

(c) Rhizobium Project

(i) The Research Officer attached to the Rhizobium Inoculaint product liquid fertilizer for soya bean under the Rhizobium Project assigned to the Institute of Fundamental Studies on 31 August 2011 by the Postgraduate Institute of Science, had been paid salaries amounting to Rs.505,500 from the provision of the Institute of Fundamental Studies in the year under review.

(ii) Even though an income of Rs.2,860,767 had been earned and expenditure of Rs.1,138,178 had been incurred in the year under review, it was observed that the Project is not a Transaction relating to the objectives of the Institute of Fundamental Studies of Sri Lanka.

(iii) Action had not been taken by the Institute to obtain the patent rights for the discovery of coir refuse planting medium used for the production the liquid fertilizer called Rhizobium Inoculaint product, discovered as a result of the experiments done by the Institute of Fundamental Studies, and as such the products of the Institute had to be marketed through 05 institutions instead of marketing directly.

4:5 Apparent Irregularities

The water bills of Institute for the year under review amounted to Rs.1,294,409. An unusual increase of charges for monthly ranging from Rs.27,668 to Rs.137,110 was observed.

4:6 Underutilization of Funds

The following observations are made.

(a) As the internal temperature of the Greenhouse No. 111A constructed at a cost of Rs.2,360,000 in the year 2010 had been high, even by March 2013 action had not been taken for its use with optimum efficiency, effectiveness and economy.

(b) The balances of 05 research funds totalling Rs.512,976 existing over a number of years had not been utilized even during the year under review.

4:7 Transactions in Suspense

Payment of Membership Fees

Even though a sum of Rs.72,112 had been paid for obtaining the membership of different institutions in foreign countries for obtaining the magazines and periodicals, it was not possible to ascertain in audit whether the Institute had actually received the magazines and periodicals.

4:8 Delayed Projects

Action had not been taken even up to 31 December 2013 for the recovery of the advance balance of Rs.1,782,802 receivable as at the end of the year under review out of the advances granted to the department of Buildings in respect of 05 construction.

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5:4 Audit Committee

The Audit Committee had not furnished its observations to the Board of Directors in terms of Section 7.4.1 of the Public Enterprises Circular No. PED/12 of 02 June 2003 and the Audit Committee had not brought the following matters to its scope.

i. Determination of the responsibilities of the Internal Audit Unit and the review of the annual audit plan.

ii. Review and evaluate internal control systems for all activities of the entity.

iii. Review of the implementation of the recommendations/ directives of the Committee on Public Enterprises.

iv. Statements on identified old slow moving and idle stocks and other items.

5:5 Budgetary Control

The annual budget had not been made use of as an instrument for the achievement of the long term goals and objectives of the year in terms of Section 5.2.5 of the Circular No. PED/12 dated 02 June 2003 of the Director General of Public Enterprises.

6. Systems and Controls

Weaknesses in Systems and Controls observed during the course of audit were brought to the notice of the Director from time to time. Special attention is needed in respect of the following areas of control.

(a) Accounting
(b) Assets Management
(c) Internal Audit
(d) Use of Motor Vehicles
(e) Conduct of Researches
(f) Personnel Management

W.P.C. Wickremaratne
Acting Auditor General