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Annual Review 2012

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Annual Review 2012
Institute of Fundamental Studies

Institute of Fundamental Studies
Hantana Road
Kandy
Sri Lanka
2012

Institute of Fundamental Studies (IFS)
Hantana Road
Kandy

Telephone: **081-2232002**
Fax: **081-2232131**
Website:**www.ifs.ac.lk**

Colombo Office
380/72, Bauddhaloka Mawatha, Colombo 7
Telephone: 011-2697538

Edited by
Prof. N.S. Kumar
Prof. S. A. Kulasooriya
Dr. N. D. Subasinghe

Programme and events coordinated by
Dr. Kumari Tilakaratne

Compiled by
S. Subramaniam

Cover design by
Gayan C.K.S. Bandara

Printed by
Sanduni Offset Printers (Pvt) Ltd.
No. 4/1, Sarasavi Uyana Good Shed Road
Sarasavi Uyana
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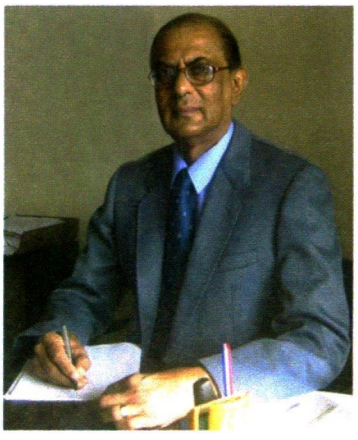
MESSAGE FROM THE DIRECTOR



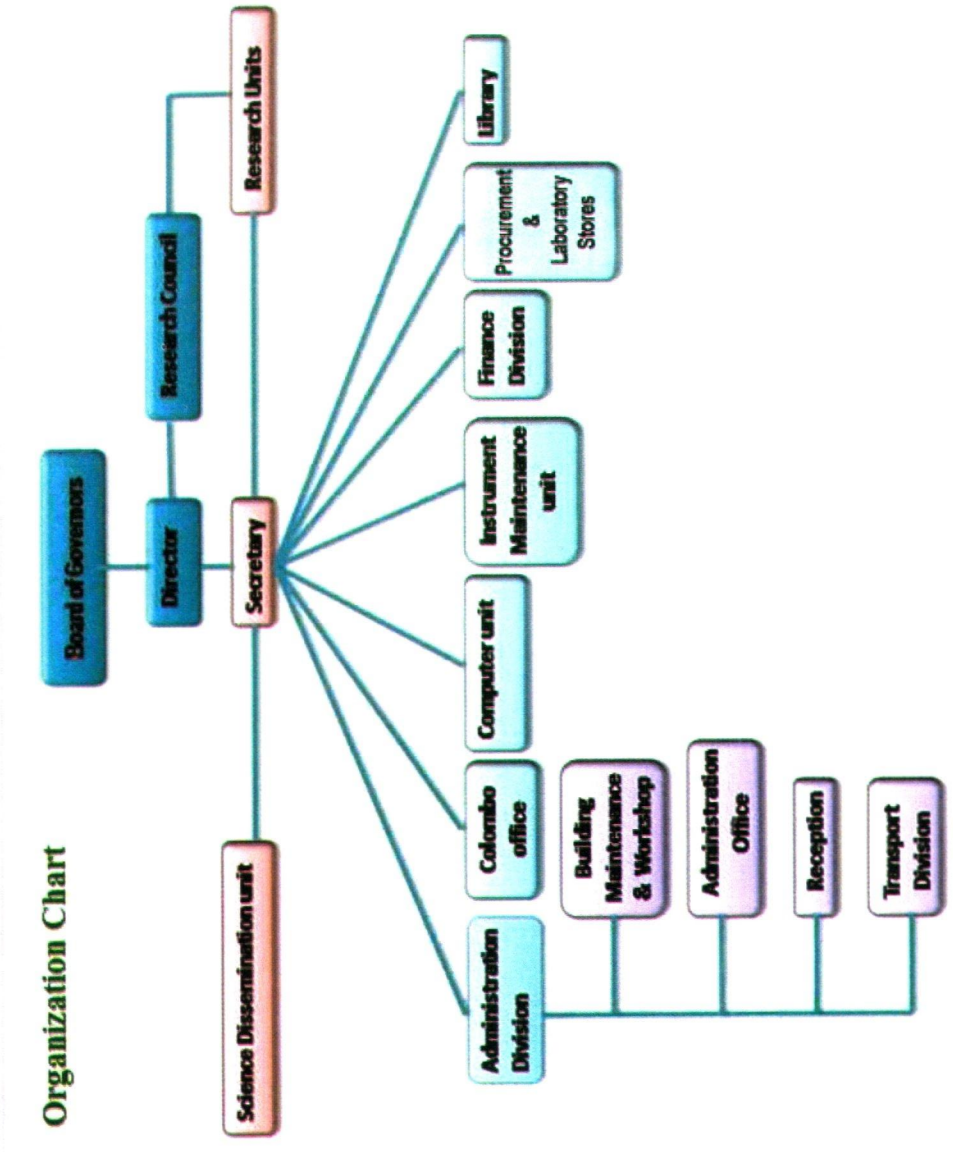
It is with great pleasure that I send this message on the occasion of the 2012 Annual Review of the Institute of Fundamental Studies. During the year under review, IFS has progressed further in its endeavor to focus on research that has an impact on national development. The basic research conducted by our scientists has benefitted the country in some sectors such as water, fertilizer, nanotechnology and photochemistry. The Consultative and Collaborative Division (CCD) has forged ahead and several new projects, with the participation of the public and private sectors, have now been established. Fifteen water defluoridation units have been installed in the dry zone of Sri Lanka and it is heartening to note that thousands of rural people are now being provided with drinking water of improved quality. The Ministry of Technology and Research is now funding this project. Foreign collaboration has shown an improvement during the past year and countries such as Korea, Japan, Australia, Denmark, Sweden, and Pakistan among others are now engaged in collaborative projects with the IFS. The training of younger scientists and school children in various aspects of science has also progressed very well and the IFS is now considered as a major postgraduate science training centre in the country.

I wish the 2012 Annual Review all success.

C. B. Dissanayake

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

Organizational Chart



GENERAL INTRODUCTION

Prof. C.B. Dissanayake, Director, IFS

The year under review 2012 has shown further progress by the Institute of Fundamental Studies. Most notably, the permanency of the scientific staff has brought about truly outstanding achievements with several scientists being acclaimed internationally with awards, memberships of prestigious scientific organizations, publications in high impact journals among others. The recent shift of emphasis for more meaningful research with clear impact on the national economy has paid rich dividends. The Consultative and Collaborative Division (CCD) and the Microbial Biotechnology Unit (MBU) in particular have shown very significant progress. It is indeed heartening to note that several government and private sector organizations are now showing greater enthusiasm to forge research links with IFS.

The Science Dissemination Unit (SDU) has continued excellent progress with large numbers of science teachers and students who have excelled in their school examinations being the main beneficiaries. The innovative and creative programmes of the SDU have received excellent feed back from the scientific community at large.

Foreign participation in IFS research activities has shown an upward trend and several countries such as Australia, Pakistan, South Korea, Denmark, Japan, Sweden are engaged in joint research activities. The infrastructure facilities are also being improved and a new building complex for the IFS is now being constructed. With the completion of this new building it is envisaged to establish new research projects of a multidisciplinary nature which would be beneficial to the country.

Training of young Research Assistants and volunteers has also progressed significantly and all universities in Sri Lanka now have links with the IFS. It is planned to increase the intake of the number of Research Assistants even further and this would almost certainly prevent, at least to some extent, the brain drain of some of our brightest young minds to foreign universities. We are indeed pleased that the IFS is now one of the major postgraduate science training institutes in the country. Excellent rapport with science faculties in universities, Post Graduate Institute of Science (PGIS), Post Graduate Institute of Agriculture (PGIA) among others has enhanced this reputation.

Finally I wish to record my sincere appreciation to H.E. the President Mahinda Rajapaksha, the Minister of Technology and Research Hon. Pavithra Wanniarachchi the Deputy Minister, Hon. Faiszer Musthahpa and the Secretary Mrs. Dhara Wijayatilake for their unstinted support to the IFS in all our activities.

From Left to Right

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GENERAL REVIEW AND SUMMARIES

7.1 ALTERNATIVE AND RENEWABLE ENERGY

7.1.1 BIOFUEL RESEARCH PROJECT

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

Invasive weeds and biofilms to produce biofuels

The increased use of fossil fuels has caused greenhouse gas emissions and created undesirable damage to the environment. Biofuels are among the promising transportation green energy sources for the future. Biofuels are classified based upon the substrate used in their production. Invasive weeds are probable raw materials for cellulosic biofuel production. These are non-indigenous or "non-native" plants which adversely affect the habitats and bioregions they invade economically, environmentally, and ecologically. For industrial scale biofuel production a continuous supply of raw materials should be assured. The fast growing nature of these weeds can provide raw materials in abundance for biofuel industries. There is a possibility of using microbial biofilms as agents of cellulose degradation due to their favourable properties. Advantages of biofilms include concentration of cell-associated hydrolytic enzymes at the biofilm-substrate interface to increase reaction rates and the physiological synergy between fungi and bacteria offers the possibility of completing delignification and saccharification in one piece of biofilm. This research was initiated in 2009 to study the microbial communities such as mixed cultures and fungal-bacterial biofilms in the simultaneous delignification and saccharification of plant substrates in order to subject the hydrolysate into biofuel production.

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

Global fossil fuel reserves are limited but the demand for energy continues to grow resulting in increased fossil fuel prices. In addition, fossil fuel usage results in net increase of atmospheric CO_2, causing global warming. Therefore, it is necessary to develop ways to utilize renewable energy sources that are eco-friendly. Biofuels are promising candidates for renewable energy. Lignocellulosic material from plant residues is a rich source of sugars and will not a cause of food versus fuel problem. However, currently it's utilization for biofuel production is not economically viable due to several factors. Therefore we will be looking at the microbiological resources that can be utilized to convert lignocelluloses into biofuel at a reduced cost.

Soil carbon sequestration and management

Carbon can be stored via sequestration for hundreds to thousands of years reducing the amount of carbon dioxide in the atmosphere. Soils are considered as potentially important terrestrial carbon sinks to meet the CO_2 emission reduction targets set by the Kyoto Protocol. This project is looking at minimizing carbon loss and maximizing the retention of carbon in soil. There are 3 sub projects under this.

Soil Carbon Sequestration in forest and tea plantations

Carbon is found in all living organisms and it is the foremost building block of life on Earth. Carbon exists in many forms, predominately as plant biomass, soil organic matter (SOM) and as gaseous carbon dioxide (CO_2) in the atmosphere and dissolved in seawater.

In soil, carbon is mainly found as soil organic carbon and soil inorganic carbon, which is crucial for better growth and development of plants. Although carbon is naturally available in the above mentioned sinks, these sinks are unable to accommodate the excessive amounts of CO_2 that humans continue to emit. Carbon sequestration implies transferring atmospheric CO_2 into long-lived pools and

storing it securely so it is not immediately reemitted (Lal 2004). In this scenario, atmospheric carbon is deposited as plant root material, incorporated into the soil microorganisms and soil organic matter (Wu et al., 2009). Removing CO_2 from the atmosphere is only one significant benefit of enhanced carbon storage (soil carbon sequestration) in soils. Other than that through sequestering C in soil quality and fertility could be improved and soil erosion could be minimized.

Various ecosystems on earth contribute in Carbon sequestration, while forest ecosystems play a major role. Forest plantations are capable of sequestering carbon while providing many other benefits. Plantation forests were originally established in Sri Lanka to provide industrial timber and fuel wood but there are other uses such as wind protection, beekeeping, and extraction of oils, dyes etc. and invaluable ecosystem services. *Eucalyptus grandis* is one of the major plantation species in Sri Lanka.

This study evaluates the contribution of these plantations on carbon sequestration and the method of enhancing sequestration through management. Simultaneously we will be studying carbon sequestration in agricultural plantations such as tea estates which provide economic benefits via carbon credits.

Home garden systems to optimize soil C sequestration

There is a great potential in storing Carbon in soils of home gardens in human settlements. After the decline of natural forests home gardens are the last remnants of land that is capable of capturing CO_2 from the environment. Although estimates of carbon storage exist for forests and forest plantations, estimates of total carbon storage in home gardens of tropics are lacking. The experiments were designed to study the effects of home gardens of different species composition in Sri Lanka on soil C sequestration and to compare them with the effects of forests in the same area.

Land use and carbon sequestration in North Sri Lanka

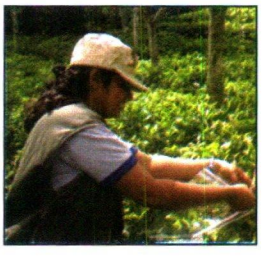
The knowledge about the relationship between soil organic carbon fractions and available nutrients would yield valuable information in managing agricultural soils. The soil organic matter improves most of the physical, chemical and biological properties that favorably affect crop production. Since soil structure also influences sequestration of C, it is important to maintain soil structure to reduce the environmental impact of agricultural practices. In this research soil nutrient availability under different land uses in Jaffna peninsula will be carried out to study the effect of carbon fractions on nutrient availability and aggregate stability of these soils. Though there have been few studies regarding nutrient availability of macro nutrients, study of micro nutrients in soils of Jaffna peninsula is limited.

Scientific Expertise: Professor S.A. Kulasooriya

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

Research Assistants : W.A.D.D. Wasalamuni, K. Mohanan, M.M.S.N. Premathileka, K.M.D. Gunathileka

Research work in progress



7.1.1.1 Bio-degradation of lignocelluloses of four invasive weeds from Sri Lanka as potential substrates for bio-fuel production

K.M.D. Gunathileke, R.R. Ratnayake, S.A. Kulasooriya

Biofuel research project, Institute of Fundamental Studies, Kandy

Introduction

Biofuel industry is a major field in which cellulose plays an important role. Mostly microbial derived cellulase enzymes are used to break complex cellulose from pretreated plant substrates into simple sugars such as glucose. An important feature of cellulose is its crystalline structure which makes it difficult to hydrolyze into simple sugars. Cellulase production is the most expensive step in the production of cellulosic biofuels such as cellulosic ethanol. Some microbial communities may significantly deviate from their component organisms living in isolation due to phenomena such as biofilm formation. A biofilm is a complex aggregation of microorganisms. Organisms living in a biofilm can have significantly different properties from free-living organisms. Hence there is a possibility that microbial biofilms could be used as agents of cellulose degradation due to their favorable properties. Biofilm organisms may increase the rates of biodegradation processes as they live inundated in a polymeric matrix which protects them and facilitates inter cellular communication.

Objectives

To isolate and identify lignocellulose degrading microorganisms; to screen the isolates for more efficient cellulolytic fungal and bacterial isolates capable of producing comparatively higher sugar yields; to develop fungal-bacterial biofilms with randomly selected isolates and efficient cellulose degrading microorganisms; to assess the efficiency of fungal-bacterial biofilms along with other fungal and bacterial monocultures and fungal mixed cultures in cellulose hydrolysis in order to produce high sugar yields and to investigate the effectiveness of sugar production from four invasive weeds abundant in Sri Lankan environment i.e *Eupatorium odoratum, Panicum maximum, Lantana camara* and *Mimosa pigra* using selected cellulolytic microbial cultures.

Results

During the second step of the study, a fungal monoculture of an *Acremonicum* spp. (code no. F23) was found to record significantly higher sugar yield compared to other monocultures and mixed cultures. Among fungal mixed cultures, the community of *Acremonium* spp. (F23) and *Fusarium* spp. (F12) was found to be one among highest sugar yielders. Among the fungal-bacterial biofilms the culture with *Acremonium* spp. (F23) and *Bacillus* spp. (B89) was effective compared to the other fungal-bacterial mixed cultures. When these cultures were inoculated into weed media the highest sugar yield was provided by the *Acremonium* spp. monoculture. Lowest was from *Acremonium* spp. and *Bacillus* spp. mixed culture. This was true to all four plant substrates. The *Acremonium* spp. monoculture produced its highest sugar yield in *E. odoratum* substrate; second highest in *P. maximum*; which were significantly higher than that from other two weeds. The fungal monoculture of *Acremonium* spp. was found to be the highest sugar yielder throughout the research. The rate of biological cellulose degradation by fungal mono-cultures did not increase with the fungal-bacterial biofilms or fungal mixed cultured tested. Yet there may be a possibility of observing such phenomena with the right combinations of microorganisms.

References

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7.1.1.2 Development of biofilms and mutant strains for ethanol production from lignocellulosic materials

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

Biofuel Research Project, IFS, Kandy

Introduction

Biofuels are promising candidates for renewable energy. 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.

Goals and Objectives

The goal of this project is to develop biofilms which can degrade lignocellulosic materials efficiently and to mutate efficient cellulolytic anaerobes to disrupt fermentative pathways leading to products other than ethanol.

To achieve this, our objectives were:

(1) Isolation of cellulolytic micro-organisms and screening them for activities of cellulases (exo/endoglucanases and β-glucosidases) and xylanases.

(2) Combining the most efficient micro-organisms to form biofilms and measuring the cellulolytic activities of the enzymes from the biofilms.

(3) Isolation of *Clostridium thermocellum* and cellulose degrading anaerobic bacteria.

Results

In addition to the 120 fungal strains and 130 aerobic bacterial strains that were earlier isolated, 43 basidiomycetes fungi were cultivated *in vitro*. The aerobic bacteria and fungi were screened for extracellular cellulase and xylanase activities after submerged culturing for 3 days. Strains showing cellulase activities of at least 0.01 FPU/ml were retested with replicates for cellulase, xylanase and β-glucosidase activities. The fungal isolates that showed the highest enzyme activities are listed below.

Isolate	Identification	Cellulase (FPU/ml)	Xylanase (IU/ml)	β-glucosidase (IU/ml)
F118	To be identified	0.21	4.31	Not detected
F80	To be identified	0.16	2.03	Not detected
F4	*Trichoderma* species	0.16	5.88	Not detected
F1	*Trichoderma* species	0.15	3.74	Not detected
F16	*Trichoderma* species	0.14	4.04	0.11
F24	To be identified	0.12	5.06	Not detected
F113	To be identified	0.06	1.02	0.15

None of the aerobic bacterial isolates showed significant extracellular enzyme activities. Therefore, the isolation of efficient cellulolytic bacteria is being attempted by using filter paper as the sole source of carbon[2].

The basidiomycetes fungi were screened for extracellular cellulase, xylanase, laccase, lignin peroxidase and Mn peroxidase activities after submerged culture for 7 days. The isolates that showed the highest enzyme activities are listed below.

Isolate	Cellulase (FPU/ml)	Xylanase (IU/ml)	Laccase (IU/ml)	Lignin Peroxidase	Mn Peroxidase
M12	0.31	6.56	1.25	0	0.08
M21	0.22	5.61	50.57	0.8	0.20
M7	0.15	6.80	0.86	0.52	0.24
M40	0.12	0	17.99	4.44	0
M5	0	1.06	1.60	0.54	1.16

Studies on biofilms will commence after the isolation of efficient cellulolyic bacteria.

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2. Immanuel, G., Dhanusha, R., Prema, P. andPalavesam, A. (2006). Effect of different growth parameters on endoglucanase enzyme activity by bacteria isolated from coir retting effluents of estuarine environment.*International Journal of Environmental Science and Technology* **3**(1) 25-34.

7.1.1.3 Chronosequential variation of Ca, Mg, K and microbial biomass carbon in a *Eucalyptus* forest plantations in Sri Lanka

M.M.S.N.Premetilake[1], R.R. Ratnayake[2], S.A. Kulasooriya[2]

[1]*Uva Wellassa University, Badulla,* [2]*Biofuel research project, Institute of Fundamental Studies, Kandy*

Introduction

Soil nutrients are one of the key factors that affect forest plantation growth. When nutrients are available in greater abundance productivity would increase (Chapin et al. 1986). Out of all the nutrients Ca, Mg and K play a major role in plant development. Ca is a key nutrient and there is a risk of significant depletion of this nutrient especially in smooth barked species (Turner and Lambert 2007). K and Mg are accumulated in the bole followed by leaves/ needles, bark, least in twigs (Sharma and Sharma 2004). Also K is crucial for many metabolic activities of plant while Mg plays a vital role in photosynthesis, being responsible for good harvest. However soil nutrient (N, P, K, and organic matter) changes were also observed where Eucalyptus was grown and compared to natural soil (*Shorea robusta*) forest in Uttar Pradesh (Jan. et al. 1996).

The soil microflora is a small but significant component in almost every ecosystem. Soil microbial activity contributes to litter decomposition and ultimately nutrient cycling. The quantity and composition of microbial biomass is sensitive to changes in the soil chemical and physical environment and organic matter quality changes as forest aged (Bauhus et al. 1998). With changes in organic matter quality, chemical and physical alterations occur in forest floor. So aging could affect quantity and composition of microbial biomass in forest plantations.

In addition the quantities of nutrient required and utilized by forest differ between species, their productivity and stage of stand development represented by age or stage of maturity (Turner and Lambert 2007). So the stand age is a key factor that influence nutrient and microbial biomass level in forest plantations and the understanding of this relationship is imperative in applying management practices to improve tree yields.

Eucalyptus is grown worldwide because of their rapid growth rates, significant responses to management treatments and their resistance environmental stresses (Turner and Lambert 2007). Several studies have been conducted to show the soil nutrient status under *Eucalyptus* plantations (Turner and Lambert 2007; Binkley and Resh 1999; Baber et al. 2006). But so far no studies have been reported on the changes MBC with stand age and its effect on soil macro nutrients. The present paper addresses how soil macro nutrient content vary with MBC and with age of *Eucalyptus grandis* forest plantations in the tropics.

Objective

To study how soil macronutrients vary with Microbial Biomass Carbon content in soil and Age of a plantation forest.

Results

There was a strong negative relationship between Ca, Mg and K in 15-30 cm layer of the soil with stand age, while Ca and K had a correlation with stand age in the 0-15 cm layer. MBC also varied significantly with the stand age. There was a relationship between Ca and K content in soil with MBC as well. However there was a rapid increase of Ca, Mg and K at the age of 28 years. The decrease of soil nutrient in the first 20 years could be due to the absorption of nutrients by the trees during their rapid growth. At the age of 28 years when the trees are mature, nutrient uptake by plants reduces causing the excess amounts of these nutrients accumulate in soil. Microbial biomass carbon reduction

in soil could be due to the amplification of monoterpene secretion with age by *Eucalyptus grandis* trees.

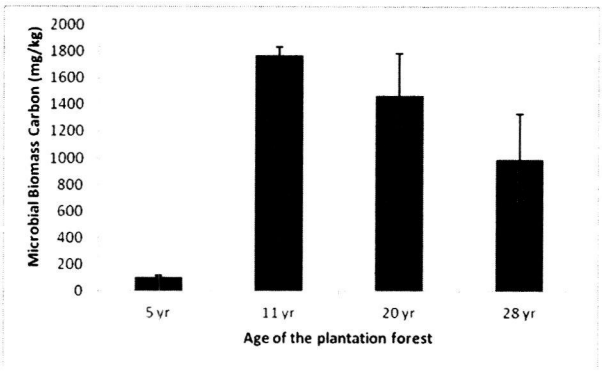

Fig. 2: Microbial Biomass carbon variation with age of the plantation

References

1. Sharma, J.C., Sharma, Y. (2004). Nutrient cycling in forest ecosystems-A review. *Agric.Rev* 25,157-172

7.1.1.4 Home garden systems to optimize soil C sequestration

W.A.D.D. Wasalamuni, R.R. Ratnayake

Biofuel research project, Institute of Fundamental Studies, Kandy

Introduction

Although estimates of carbon storage exist for forests and forest plantations, estimates of total carbon storage in home gardens of tropics are lacking. The objective of the current study was to study the effects of home gardens of different species composition in the wet zone of Sri Lanka on soil C sequestration. The study sites in the mid country wet zone consist of three home gardens with different species composition and a natural forest (wet evergreen forest) in the same zone. Home garden (HG 1) – Kandyan forest garden; Home garden (HG 2)- Kandyan forest garden; Home garden (HG 3)- Home gardens incorporated with Spice crops.

Results

According to the results KHG2 had significantly high values for MBMC, MBMN and % total Organic C when compared with the other sites and forest soil. KHG2 also had fewer disturbances due to the minimum management practices, which was indicated by its low content of $KMnO_4$ oxidizable organic C. The species richness and the species density were also high within the site. Therefore KHG 2 has a high potential of soil C sequestration compared with the other two sites and forest soil. The study indicated that traditional Kandyan home gardens with high species richness and minimum management practices have a high potential of soil C sequestration.

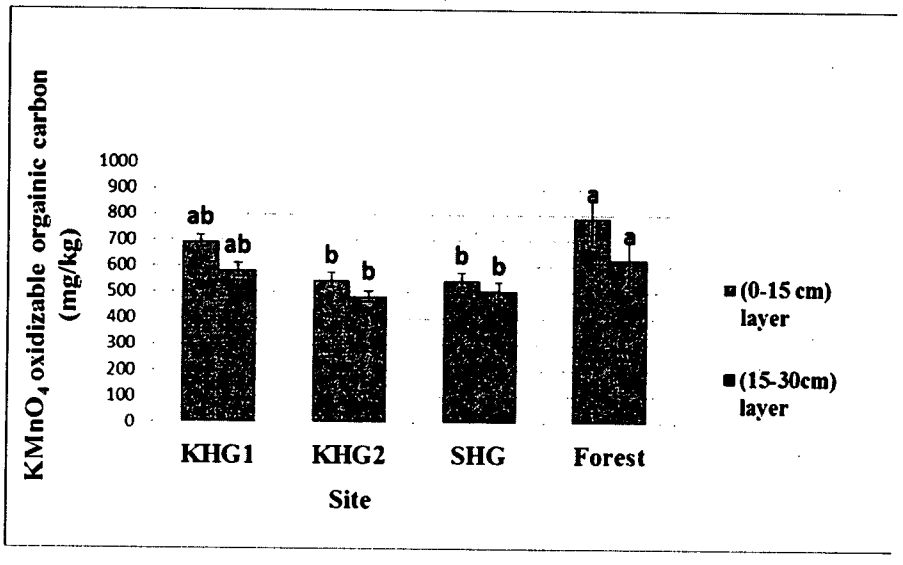

Fig. 01: Soil $KMnO_4$ oxidizable organic C variation among sites

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1. Montagnini, F., Nair, P.K.R. (2004) Carbon sequestration: an under-exploited environmental benefit of agroforesty systems. *Agroforest. Syst.* 61, 281-298.

7.1.1.5 Available nutrients in soils under different agricultural land –uses and their links to carbon fractions and soil properties

T. Roshantan[1], R.R. Ratnayake[2]

[1]Faculty of Agriculture, University of Jaffna, [2]Biofuel research project, Institute of Fundamental Studies, Kandy

Introduction

The balance of soil carbon is greatly influenced by human activities, including various land uses. The soil carbon stocks can be increased by various carbon sequestration strategies.

Soil organic matter enhances nutrient availability to crops not only as a source of nutrients but also by chelating effects of micro nutrients. Nutrient status in soil is important in decomposition activities of soil and thereby the C fractions of soil. The knowledge about the relation between available nutrients and soil organic carbon fractions would yield valuable information in managing agricultural soils.

This research aims to quantify and compare the available soil nutrients, soil texture and structural stability of different agricultural land uses in Jaffna district to study their effects on the available carbon fractions. The results will help to understand the behavior of soils to manage them effectively. Though there have been few studies regarding nutrient availability of macro nutrients, study of micro nutrients in soils of Jaffna peninsula is limited. This study is a continuation of a previous study on "Carbon stock assessment of various land uses in Jaffna district".

Result

The study showed that land uses had significant variations in terms of organic carbon stocks, nutrient availability and aggregate stability. Primary macro nutrients such as nitrogen, phosphorous and potassium availability ranged between 9.92-29.72 ppm, 3.33 - 31 ppm, and 43.67 - 374.15 ppm respectively. Secondary macro nutrients such as calcium and magnesium availability ranged between 250.47 - 3929.13 ppm and 54.97 - 312.63 ppm respectively. The micro nutrients such as zinc, iron, copper and manganese availability ranged between 0.25 - 11.15 ppm, 13.29 – 35.37 ppm, 0.46 – 4.06 ppm and 7.12 – 31.61 ppm respectively in different land uses. Aggregate stability value ranged between 0.17 – 4.11 and had positive trend with carbon fractions. The texture of soils varied from sandy loam, loamy sand and sand and it also varied in depth wise in few land uses. For most nutrients, availability had a weak positive trend with carbon fractions. Aggregate stability also showed positive trend with clay content of soil.

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1. Bonilla, D., Plaza, C., Cantero, M., Fuentes, J.A. (2010). Tillage effects on soil aggregation and soil organic carbon profile distribution under Mediterranean semi-arid conditions, *Soil Use Manage.* 26, 465-468.

Human Resource Development

a) Research Assistants who have completed post graduate studies

K.M.D. Gunathileka- M.Phil.-2012
Thesis title: Microorganisms and microbial biofilms as agents of cellulosic biodegradation of invasive weeds in Sri Lanka

b) Research Assistants registered for post graduate studies

1. M.M.S.N. Premathileka (Ph.D.)
   Thesis title: Soil carbon sequestration in forest plantations of Sri Lanka
2. W.A.D.D. Wasalamuni (M.Phil.)
   Thesis title: Potential of soil carbon sequestration in home gardens of Sri Lanka
3. K. Mohanan (M.Phil.)
   Thesis title: Development of microbial strains and biofilms for efficient production of ethanol from cellulosic materials

c) Research students (M.Sc., B.Sc.) & Trainees

1. Anuradhi Ekanayake (Graduate student-Florida State University, USA)
2. Roshanthan (B.Sc. Student – University of Jaffna)
3. R. Somaratne (B.Sc. Student – Rajarata University of Sri Lanka)
4. Chaminda Alahakoon (Pre university research student)
5. Supun Galappaththi (Pre university research student)

7.1.2. CONDENSED MATTER PHYSICS AND SOLID STATE CHEMISTRY

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

Objective of the Projects

During 2012, the research activities of the Condensed Matter Physics and Solid State Chemistry Projects at IFS were largely focused on (1) efficiency enhancement of dye sensitized solar cells based on liquid, solid and gel type electrolytes, (2) synthesis and characterization of solid and gel polymer electrolytes for possible applications in Electrochromic displays and (3) design and testing of a polymer nanofiber, antibacterial water filter.

Description of research projects

1. Efficiency enhancement of dye sensitized solar cells based on liquid, solid and gel type Electrolytes

(a) Efficiency enhancement in dye sensitized solar cells by mixed cation effect

Photoelectrochemical (PEC) solar cells based on nanostructured, dye-sensitized titanium dioxide (TiO_2) have attracted worldwide attention as a low cost alternative to conventional silicon and thin film solar cells. A typical dye-sensitized solar cell (DSSC) consists of a semi-transparent dye-sensitized, nano-porus, nanocrystalline TiO_2 film, an electrolyte with a redox couple and a Pt coated counter electrode. These dye-sensitized solar cells generally employ a solvent electrolyte based on acetonitrile and a I^-/I_3^- redox couple and have impressive energy conversion efficiencies reaching around 11%. However, a major drawback of these solution based solar cells, originally developed by Gratzel and coworkers, is the lack of long-term stability due to liquid leakage, usage of volatile liquids such as acetonitrile, electrode corrosion, and photodecomposition of the dye in the solvent medium. In order to overcome these problems, many efforts are being made to replace the liquid electrolyte by gel polymer electrolyte (or quasi-solid electrolyte). The gel electrolytes used in majority of DSSC research consist of anion conductors and in most cases these are iodide ion (I^-) conductors. The iodide ion conductivity contribution to the overall ionic conductivity of the electrolyte in a DSSC is a major factor which determines the short circuit current density (J_{SC}) and hence the efficiency of a DSSC. Although iodide ion conductivity is an important parameter in determining the short circuit photocurrent and the efficiency of DSSCs, not much systematic research work has been reported on this aspect.

While bulky cations such as Pr_4N^+ and Hex_4N^+ are expected to minimize the cationic conductivity and enhance the iodide ion conductivity in the electrolyte, cations with high charge density, such as K^+, Li^+ or Na^+ are expected to contribute towards better photogeneration of electrons at the dye and faster diffusion dynamics at the dye–semiconductor interface. Therefore, it would be natural to explore the combined effect of using a binary mixture of two iodide salts consisting of a bulky cation and a small alkali cation with high charge density in the electrolyte in order to benefit from both above mentioned mechanisms. **With this idea in mind, we have studied several gel electrolyte systems which are described under research summaries:**

(b) The use of blended polymer matrices and binary mixed cation iodide salts in the electrolyte on the efficiency enhancement of Ruthenim dye sensitized TiO_2 solar cells is investigated. Tetrapropylammonium iodide ($Pr_4N^+I^-$) and potassium iodide (KI) were employed with the blend of poly(vinyldiene-fluoride) (PVdF) and polyethelne oxide (PEO). Enhancement in the efficiency of these cells is further investigated with the addition of ionic liquid 1-ethyl-3-methylimidazolium-bis (trifluoromethylsulfonyl) imide (EMITFSI) and several different nano size fillers in the above electrolyte. Out of various compositions studied, the best solidified polymeric electrolyte with the

composition of PVdF (5.62 %): PEO (5.62%): PC (39.39 %): EC (39.39%): ACN (1.35 %): KI (1.12 %) I_2 (0.05 %): $Pr_4N^+I^-$ (4.5 %): EMITFSI (1.80%): TiO_2 (1.12%): by weight ratio, showed the best photo-conversion efficiency of 5.5% under the irradiation of simulated sunlight 100 mW cm^{-2} (AM 1.5).

2. Synthesis and characterization of solid and gel polymer electrolytes for possible applications in Electrochromic displays

Electrochromism can be used in devices such as "smart windows" for energy-efficient architecture, variable reflectance mirrors, display devices of many different types. Such windows generally consists of a sandwich structure with a transmissive WO_3 thin film on ITO and a transmissive thin film of CeO_2 on ITO, which are separated by electrolyte. In most cases, the electrochromic display device has been constructed as a solution-containing system using a solution electrolyte. Hence the inevitable drawbacks to electrochromic display devices are the leakage of electrolyte solution, weight gain from the solution and low chemical stability of the solution. Therefore, it is expected that the development of solid-state ionic conductors involving either protons or lithium ions will improve these drawbacks and lead to the possibility of using the devices in a wide display area. Keeping these in mind we have been exploring the possibilities of using quasi solid state polymer electrolytes and use of non conventional cheaper materials like TiO_2 in electrochromic displays.

3. Design and testing of a polymer nanofiber, antibacterial water filter.
(NRC 11-53 Research Projects)

(a). Polymer Nanofibres for Water Filtration

Supplying safe and clean drinking water to millions of people living in the developing world has become an acute problem which has drawn the attention of governments and international agencies. In Sri Lanka also, as in many other developing countries, many people, especially those living in under developed areas of the country, are faced with the problem of accessing safe and clean drinking water. Often, people in these areas drink water collected from streams, canals, lakes, reservoirs and ground wells, with a high risk of getting waterborne diseases which could have deadly effects in some cases.

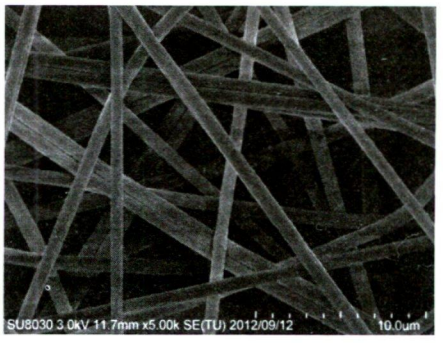
One of the objectives of the NRC funded research project at the IFS is to find a suitable polymer nanofibre which could be used, along with other active materials, as the main filter medium in a newly designed portable, antimicrobial, domestic water filter. The performance of the new water filter will be tested using water from different types of sources from different areas of the country.

(b) Polymer nanofibers for Dye Sensitized Solar Cells

Dye sensitized solar cells are emerging as the next generation of solar cells, mainly due to their low fabrication cost compared to conventional silicon based solar cells. Among them, gel polymer or "quasi-solid polymer" electrolytes are preferred over liquid electrolytes due to many advantages, such as ease of handling and fabrication, stability and geometrical flexibility even at the expense of somewhat lower efficiency (currently about 3-4 %). A new direction has recently been opened up due to the possibility of using polymer nanofibres as the electrolyte medium in these solar cells. Research is needed to find suitable polymer nanofibre electrolytes which can yield higher efficiencies, of the order of 4-7 % , in dye sensitized solar cells.

The objective of the NRC funded research project at the IFS is to find one or more polymer or gel polymer nanofibre electrolyte, which could be used in dye sensitized solar cells to achieve higher efficiencies.

The IFS Nano Team members inspect the polymer nanofiber films prepared for the anti microbial water filter and dye sensitized solar cells. L to R: Mr. Chathuranga Ekanayake, Prof. C.B. Dissanayake, Prof. Lakshman Dissanayake, Ms. Nalika Divarathne and Dr. Rohan Senadeera.



SEM photo of a Polymer Nanofiber mat fabricated at the IFS, Kandy to be used for antimicrobial water filters and dye sensitized solar cells.

Collaborations:

i) Prof. B.-E. Mellander, Chalmers University of Technology, Sweden , on dye sensitized solar cells.
ii) Prof. S. Sivananthan, Dr. Ramesh Dhere, Sivananthan Laborotories, Inc., and University of Illinois at Chicago, USA on CdS/CdTe solar cells.
iii) Prof. A.K. Arof, University of Malaya, KL, Malaysia on dye sensitized solar cells.
iv) Dr. V.A. Seneviratne, Department of Physics, University of Peradeniya, on technologically important novel materials.
v) Prof. P. Ravirajan, University of Jaffna on CdS/CdTe solar cells.
vi) Dr. T.M.W.J. Bandara , Rajarata University of Sri Lanka, on dye sensitized solar cells.
vii) Prof. Piyasiri Ekanayake, University of Brunei Darussalam, Brunei on Dye sensitized solar cells.
viii) Prof. I.M. Dharmadasa, Sheffiled Hallam University, UK on Solar Energy Applications.

Research Assistants: Mr. C.A. Thotawatthage (Research Assistant)
Ms. W.N.S. Rupasinghe (Research Assistant)
Ms. S.L. Jayaratne (Research Assistant)
Ms. H.K.D.W.M.N.R. Divarathne (NRC Research Student)
Mr. P.M.P.C. Ekanayake (NRC Research Student)
Ms. W.J.M.J.S.R.Jayasundara (Ph.D. Student from PGIS/Rajarata University
Ms. Ms. H.M.N. Sarangika (Prob. Lecturer from Sabaragamuwa University)

Condensed Matter Physics and Solid State Chemistry Research Group (2012)

7.1.2 DSSC systems studied during 2012:

7.1.2.1 Efficiency enhancement in dye sensitized solar cells with mixed cation gel electrolyte PAN:EC:PC:Pr_4NI:KI

M.A.K.L. Dissanayakea[1], C.A. Thotawatthage[1], G.K.R. Senadeera[1], T.M.W.J. Bandara[1], W.J.M.J.S.R. Jayasundera[1], B.-E. Mellander[2]

[1]Condensed Matter Physics and Solid State Chemistry Projects, IFS
[2]Chalmers University of Technology, Gothenburg, Sweden

With identical electrolyte compositions, the solar cell with 100% (w/w) KI showed an efficiency of 4.98 % and the cell with 100% (w/w) Pr4NI showed an efficiency of 4.47 %. However, the cell with the mixed iodide system, 16.6% (w/w) KI + 83.4%(w/w) Pr4NI showed the highest efficiency of 5.36 %. This is about **20% enhancement in efficiency** compared to the DSSC using Pr4NI only as the iodide salt.

7.1.2.2 DSSCs based on PAN gel type polymer electrolytes containing a mixture of $Pr_4N^+I^-$ and MgI_2 iodide salts

M.A.K.L. Dissanayakea[1], C.A. Thotawatthage[1], G.K.R. Senadeera[1], T.M.W.J. Bandara[1], W.J.M.J.S.R. Jayasundera[1], B.-E. Mellander[2]

[1]Condensed Matter Physics and Solid State Chemistry Projects, IFS
[2]Chalmers University of Technology, Gothenburg, Sweden

These electrolytes have been prepared by incorporating the plasticizers EC and PC. With identical electrolyte compositions, the cell with MgI_2 alone gave an efficiency of 2.5 % and the cell with Pr_4NI alone gave an efficiency of 4.1 %. The cell with the mixed iodide system, MgI_2: Pr_4NI = 18.4:81.6 (molar ratio), however, showed an enhanced efficiency of 5.18 % with a short circuit current density (J_{sc}) of 11.99 mA cm^{-2}, open circuit voltage (V_{oc}) of 727.5 mV and a fill factor of 59.4 %. This is an **enhancement of 26%** which we believe is a significant research finding.

7.1.2.3 Efficiency enhancement in DSSCs based on *PAN/EC/PC:$Hex_4N^+I^-$:MgI_2 gel electrolyte*

T.M.W.J. Bandara[2], M.A.K.L. Dissanayake[1], W.J.M.J.S.R. Jayasundara[1], I.Albinsson[3], B.-E. Mellander[3]

[1]Condensed Matter Physics and Solid State Chemistry Projects, IFS, [2]Rajarata Univesity, Mihinthale, Anuradhapura, [3]Chalmers University of Technology, Gothenburg, Sweden

DSSCs were fabricated and characterized with the gel electrolyte PAN/EC/PC:$Hex_4N^+I^-$:MgI_2 . The best cell using the electrolyte with 100 % $Hex_4N^+I^-$ and 20% MgI_2 with respect to PAN weight showed the maximum of 3.5% energy conversion efficiency and 8.6 mA cm^{-2} short circuit current density.

7.1.2.4. Mixed cation effect in enhancing the efficiency of dye sensitized solar cells based on polymethylmethacrylate (PMMA) and nanoporous titanium dioxide (TiO_2)

M.A.K.L. Dissanayake[1], R. Jayathissa[2], V.A. Seneviratne[2], C.A. Thotawatthage[1], G.K.R. Senadeera[3]

[1]Institute of Fundamental Studies, Hantana Road, Kandy, [2]Department of Physics, University of Peradeniya, Peradeniya, [3]Department of Physics, The Open University of Sri Lanka, Nawala, Nugegoda

The electrolyte containing 100 wt % KI showed a solar cell efficiency of 3.39 % while the cell containing an electrolyte with 100 wt % Pr4N+I- showed an efficiency of 3.21 %. However the electrolyte containing the iodide salt mixture with 22.2 wt% KI and 77.8wt% Pr4N+I- exhibited the best solar cell efficiency of 3.99 % highlighting the influence of the mixed cation effect on enhancing the efficiency of these solar cells. The **efficiency enhancement in this DSSC system is about 18%.**

7.1.2.5 Efficiency enhancement by mixed cation effect in dye-sensitized solar cells with a PVdF based gel polymer electrolyte

A.K. Arof[1], M.F. Aziz[1], M.M. Noor[1], M.A.Careem[3], L.R.A.K. Bandara[3],C.A. Thotawatthage[2] W.N.S. Rupasinghe[2], M.A.K.L. Dissanayake[2,3]

[1] Centre for Ionics University of Malaya, Physics Department, University of Malaya,50603 Kuala Lumpur, Malaysia[2] Institute of Fundamental Studies, Kandy, [3]Department of Physics, University of Peradeniya, Peradeniya

With identical electrolyte compositions, the solar cell with KI alone gave an efficiency of 2.37 % and the cell with Pr_4NI alone gave an efficiency of 2.90 %. The cell with the mixed iodide system, KI: Pr_4NI = 16.6:83.4 (% weight ratio) however, showed an enhanced efficiency of 3.92 % . The efficiency **enhancement here is about 35%.**

7.1.2.6 Efficiency enhancement in dye-sensitized solar cells by mixed cation effect with PEO:EC:PC: Pr_4NI:KI Electrolyte

M.A.K.L. Dissanayake[1], E.M.B.S. Ekanayake[2,3], L.R.A.K. Bandara[2], V.A. Seneviratne[2], C.A. Thotawatthage[1], G.K.R. Senadeera[1,4]

[1]Institute of Fundamental Studies, Hantana Road, Kandy, [2]Department of Physics, University of Peradeniya, [3]Postgraduate Institute of Science, University of Peradeniya, [4]Department of Physics, The Open University of Sri Lanka, Nawala, Nugegoda

In the polyethylene oxide (PEO) based gel electrolyte PEO:EC:PC: Pr_4NI:KI Electrolyte based DSSC system, the cells with 100 wt % KI and 100 wt % (Pr_4NI) efficiencies under AM 1.5 illumination are 3.87% and 3.75%, while 16.67 : 83.33 w% KI : Pr_4NI salt mixture shows the highest efficiency of 4.44 %. **This is an efficiency enhancement of about 15 %.**

7.1.2.7 Efficiency enhancement in DSSCs based on *PEO:$Pr_4N^+I^-$:KI:PC:I_2 by nano-filler effect*

M.A.K.L. Dissanayake, C.A. Thotawatthage, G.K.R. Senadeera, W.N.S. Rupasinghe, V.A. Senevirathne

Condensed Matter Physics and Solid State Chemistry Projects, IFS

The efficiency of the DSSC with 100 wt% $Pr_4N^+I^-$ is3.12% and the efficiency with 100 % KI is 3.79%. However, the efficiency of the DSSC with 75wt% KI and 25 wt% Pr_4N^+I is 4.2%. The efficiency enhancement due to incorporation of the binary iodide mixture is **about 10%.** The addition of 2.5 wt% nano TiO_2 filler to the electrolyte resulted a further enhancement of efficiency up to **5.31%.**

Conclusions

Dye sensitized solar cells employing a binary mixture of two iodide salts, one with a bulky cation and the other with a smaller cation with high charge density, can give rise to a significant efficiency enhancement essentially due to the increased short circuit photocurrent and this effect appears to be related to the high iodide ion conductivity in the electrolyte. **We believe that this is an important research finding by our group in the area of dye sensitized solar cell research.**

7.1.2.8 Studies On Quasi Solid State Electrochromic Smart Windows Based on TiO_2 and SnO_2

M.A.K.L. Dissanayakea, C.A. Thotawatthage, G.K.R. Senadeera, H.M.N. Sarangika

Condensed Matter Physics and Solid State Chemistry Projects, IFS

A new quasi solid state electrochromic display device with the cell configuration TiO_2/Poly(methyl methacrylate)(PMMA) electrolyte/SnO_2 has been fabricated and tested its electrochromic properties. A reversible color change between blue and colorless was observed when an appropriate potential was applied repeatedly to the device. The structure of the electrolyte is X-ray amorphous. Its ionic conductivity passed by a maximum of 1.5×10^{-4} S/cm for a lithium concentration of 0.5 g/7.5 ml. The value increases with temperature and follows an Arrhenius law with an activation energy of 49.5

kJ/mol. A transmission change at 510 nm between 65% (bleached state) and 0.26% (colored state). The preliminary studies of the stability of the devices has been tested by cycling them between the colored and bleached states at potentials of -0.25 V and +4.0V (90 s), respectively, and after the potential stepping of 1000 times no loss on the transmittance response was observed.

7.1.2.9 Development and characterization of polymer nano fibres for antimicrobial water filtration

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

[1]Institute of Fundamental Studies, Hantana Road, Kandy, [2]Department of Chemsitry, University of Peradeniya, , [2]Department of Soil Science, University of Peradeniya, [4]Department of Physics, The Open University of Sri Lanka

One of the objectives of the NRC funded research project at the IFS is to find a suitable polymer nanofibre which could be used, along with other active materials, as the main filter medium in a newly designed portable, antimicrobial, domestic water filter. Polymer nano fibers have been prepared using the electrospinning technique. These have been characterized by SEM. Polymer nano fibers have been used to fabricate a low cost, portable water filter. The performance of the new water filter has been tested using water from different types of sources.

7.1.2.10 Development and characterization of polymer nano fibres for efficient dye Sensitized Solar Cells

M.A.K.L. Dissanayake[1], C.B. Dissanayake[1], H.K.D.W.M.N.R. Divaratne[1], B.M.R. Bandara[2], S.V.R. Weerasooriya[3], G.K.R. Senadeera[4]

[1]Institute of Fundamental Studies, Hantana Road, Kandy, [2]Department of Chemsitry, University of Peradeniya, , [2]Department of Soil Science, University of Peradeniya, [4]Department of Physics, The Open University of Sri Lanka

Dye sensitized solar cells can be manufactured at a lower fabrication cost compared to conventional silicon based solar cells. Among them, gel polymer or "quasi-solid polymer" electrolytes are preferred over liquid electrolytes due to many advantages, such as ease of handling and fabrication, stability and geometrical flexibility even at the expense of somewhat lower efficiency (currently about 3-4 %). A new direction has recently been opened up due to the possibility of using polymer nanofibres as the electrolyte medium in these solar cells. Research is needed to find suitable polymer nanofibre electrolytes which can yield higher efficiencies, of the order of 4-7 %, in dye sensitized solar cells.

Under the NRC funded research project at the IFS we have synthesized polymer gel nanofibre electrolyte, which could be used in dye sensitized solar cells to achieve higher efficiencies. Our group has successfully synthesized polymer nanofibres and fabricated dye sensitized solar cells using gel electrolytes incorporating polymer nanofibres. These cells exhibit higher efficiencies compared to normal gel electrolyte based cells.

Human Resource Development.

Ph.D, M.Phil., M.Sc. students, undergraduate students; trained during 2012 with their affiliations; completed and passed out during 2012

Postgraduate students trained/supervised during 2012:

1. Ms. W.N.S. Rupasinghe (Research Assistant, M.Phil. PGIS, training continued)
2. Ms. S.L. Jayaratne (Research Assistant, M.Phil. PGIS, training continued)
3. Ms. HKDWMNR Divarathne (NRC Research Student, M.Phil. PGIS, training continued)
4. Mr. P.M.P.C Ekanayake (NRC Research Student, M.Phil. PGIS, training continued)
5. Ms. W.J.M.J.S.R.Jayasundara (Ph.D. Student from PGIS/Rajarata University, Training continued).
6. Ms. H.M.N. Sarangika (Probationary Lecturer, Sabaragamuwa University, M.Phil/Ph.D. PGIS, University of Peradeniya, training continued)
7. Cmdr. C.I.F. Attanayake- PhD Student- to be completed - Moratuwa University of Sri Lanka , training continued)
8. Mr. Y.P.Y.P. Ariyasinghe- M.Phill- Open University of Sri Lanka (former Research Assistant - Institute of Fundamental Studies, Thesis writing)
9. Mr. T.R.C.K. Wijayaratna- M.Phill – Open University of Sri Lanka (former Research Assistant - Institute of Fundamental Studies, Thesis under review).
10. Ms. Rasanjali Jayathissa (M.Sc in Nanoscience & Nanotechnology, completed in November 2012) , PGIS, University of Peradeniya.
11. Mr. E.M.B.S. Ekanayake (M.Sc. Physics of Materials, PGIS, University of Peradeniya. Project completed, Report under review)
12. Mr. T. Balashangar (Univ of Jaffna ,completed a part of his M.Phil. training)
13. Mr. M.F.B. Abdul Aziz (M.Sc. student, University of Malaya, Malaysia; Spent 4 months at IFS)
14. Mr. Roshan Kumara, (PhD student, University of Brunei Darussalam, Spent 1 month at IFS for training)
15. Ms. Komadi Manjula (M.Sc. Physics of Materials, PGIS, University of Peradeniya Project abundant due to pregnancy)
16. Mr. Suranga Nawarathne (M.Sc in Nanoscience & Nanotechnology, training continued)
17. Mr. M.R. Nishantha (M.Phill- OUSL, completed a part of his M.Phil. training and obtained the degree)
18. Ms. C.N. Nupearachchi (M.Phill- OUSL , spent one month at IFS for her M.Phil. training, Mphill Completed)

Undergraduate students trained during 2012:

1. Ms. Kiruthika from EUSL (completed her undergraduate research project)
2. Mr. W.A.R.B. Weerasekera (OUSL, continuing his undergraduate research project)

7.1.3 GEOTHERMAL ENERGY

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

Geothermal resources mapping project

Research Overview

Geothermal energy is a clean renewable energy source. In fact, the environmental impact of a geothermal power plant is minimal, compared to that of other renewable energy sources such as hydroelectricity or photovoltaic panels. At a time when the hydroelectricity capacity of the country has already been reached, it is necessary to search for new sources of renewable energy, to reduce the country's dependence on imported fossil fuels. IFS has taken the initiative to evaluate the potential of our geothermal resources for the benefit of the country.

Although Sri Lanka does not have high-enthalpy geothermal fields similar to those found in volcanic regions, there is strong evidence to believe that some of our hot-springs may have a potential to be used as energy sources. Geothermal sources closely follow the geological boundary between Highland and Vijayan lithological complexes, suggesting a possible relationship between the geothermal resources and the boundary. One of the objectives of the geothermal resources mapping project is to investigate this relationship between the hot springs and the Highland-Vijayan boundary.

Geophysical Investigations

Modern remote sensing geophysical techniques such as Magneto-telluric (MT) and Time domain electromagnetic (TDEM) techniques, when used in combination, are capable of collecting data on structural features, down to tens and hundreds of kilometres. MT and TDEM surveys were conducted in potential geothermal areas with the support of British, Canadian and local scientists. TDEM provides high-resolution profiles near the surface while MT provides information in the kilometre scale. Our own postgraduate students are processing the geophysical data collected, using the knowledge and training received during overseas training.

Geochemical investigations

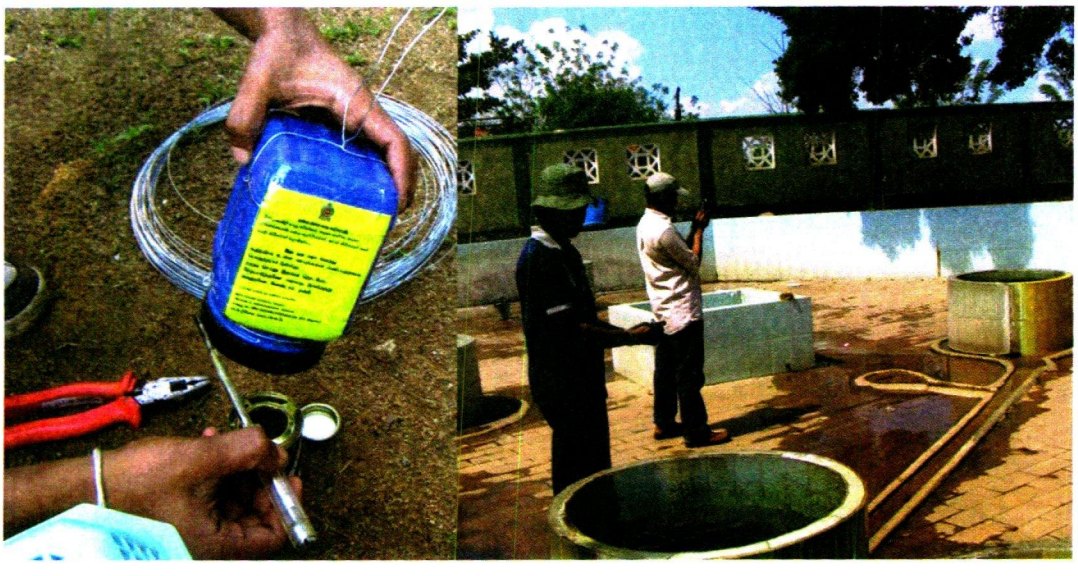
Geochemical analyses may help to understand the origin of the thermal spring's water. Chemical geothermometry can be used for calculating the reservoir temperatures. Silica (quartz, chalcedony, amorphous silica etc.) and alkali geothermometers (Na–K, Na–Li, Na–K–Ca etc.) are the most popular for this purpose. The latest silica geothermometer is the modified silica geothermometer introduced by Verma and Santoyo (1997). It produced the following figures for the reservoir temperatures of the thermal springs.

Location	Mahapelessa	Rankiri Ulpotha	Kanniya	Nelumwewa	Maha-oya	Padiyathala-wa	Kapu-rella
Temperat-ure (°C)	**118**	**133**	**105**	**137**	**121**	**138**	**128**

Radon Mapping Programme

As a part of the geothermal resource mapping, radon mapping programme was also initiated in collaboration with the Atomic Energy Authority (AEA) of Sri Lanka and the National Institute of Radiological Sciences (NIRS), Japan. This is the first ever radon monitoring programme in Sri Lanka. One of the objectives of this programme is to determine if there are any anomalous radon levels around the geothermal springs, as this would be an indication that the geothermal springs are originating from deep down in the earth. It is a known fact that radon gas is emitted from the opening of the earth and, consequently, most of the thermal waters in other countries are rich in radon. Radon, being the heaviest noble gas, is radioactive. ^{222}Rn is emitted by radioactive decay of uranium, while ^{220}Rn, commonly known as *Thoron*, is emitted by thorium decay. Preliminary results indicate that thoron concentrations are higher in Sri Lanka, compared to most of the other countries of the world. This is an indication that Sri Lanka has abundant amounts of thorium-containing minerals.

The radon mapping program may help to identify the areas with potentially hazardous radon levels (if any) as well as the hitherto unknown radioactive mineral resources.



Left: Installing passive radon detectors in a custom built housing which provides protection from the elements. *Right:* Investigating the thermal springs at Maha Oya

Estimate of the Eppawala Phosphate Ore

A new research project was initiated to estimate the subsurface content of the Eppawala Phosphate ore using geophysical methods. Since secondary phosphates as well as primary parent materials contain higher-than-average magnetite and other iron minerals, geo-magnetic techniques can recognise the magnetic signature, which will help to map the boundaries of the mineral deposit accurately. This project is supported by a grant from the National Science Foundation of Sri Lanka.

Research Assistants: N.B. Suriyaarachchi, T.B. Nimalsiri, D.R. Charles, (NSF Grant)
Technical Officer: S. Opatha
Technical Assistant: Mr. A.K. Tennakoon (NSF Grant)

L to R: Mr. D.R. Charles (Research Asst.), Mr. T.B. Nimalsiri (Research Asst.), Mr. N.B. Suriyaarachchi, (Research Asst.), Dr. N.D. Subasinghe (Project Leader), Mr. A.K. Tennakoon (Technical Assistant) and Mr. O.K.S. Opatha (Senior Technical Officer)

7.1.3.1 Near surface resistivity profiling of Kapuralla hot-spring area using TEM data

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

Geothermal Energy Project, Institute of Fundamental Studies, Hantana Road, Kandy, Sri Lanka

Abstract

As a part of the geothermal resources mapping, Time-domain electromagnetic (TEM) data were collected around the thermal springs in Sri Lanka. These data can provide a well-resolved resistivity profiling down to about 200 metres. Magneto-telluric (MT) data may provide information on deeper structures, but lack details on near-surface structures. Combination of the two techniques is necessary to construct useful resistivity profiles. The subsurface resistivity profile of Kapuralla hot-spring area, created using TEM data, is presented here. Possible channels.

Introduction

Sri Lanka has several hot-springs that can be considered as potential sources of geothermal energy. Resistivity profiling of the geothermal areas may reveal the sub-surface structures including the heat source and the path of ground water flow. MT and TEM, two geophysical techniques, are used in combination to construct a resistivity profile.

Aims & Objectives

This study on resistivity profiling in areas around geothermal resources in Sri Lanka was started with the following aims and objectives:

1. To construct sub-surface structures of the area and to find other possible locations for hot springs.
2. To understand the sources of heat and the water.

Methodology and Results

Geophysical investigations using TEM and MT were employed. TEM data provide more detailed information on depths of about 200m. A resistivity profile constructed using TEM data is presented in Fig. 1.

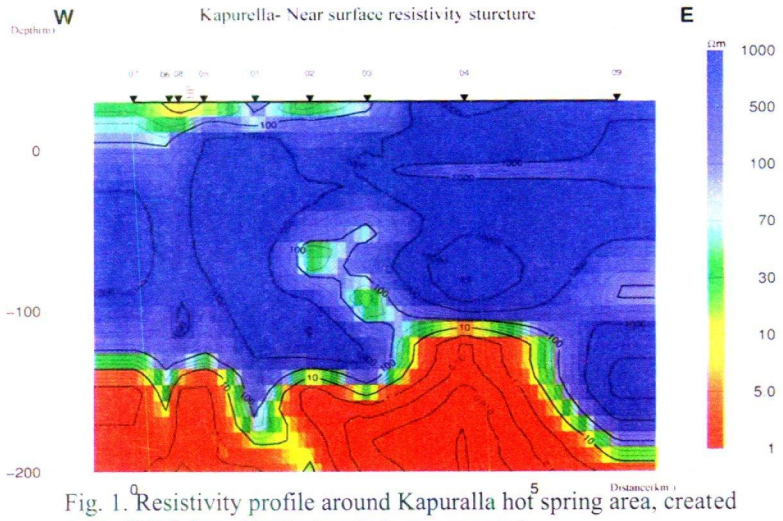


Fig. 1. Resistivity profile around Kapuralla hot spring area, created using TEM data. Vertical scale is exaggerated.

Discussion and Conclusions

As indicated in Fig. 1, there are prominent low resistive regions about 120 m below the surface. These regions may represent the aquifers or fractures that carry groundwater. Vertical low-resistive zones indicate the possible vertical channels, through which the groundwater surface as hot springs. Field investigations also supported the existence of a cluster of springs in Kapuralla area as indicated by TEM results.

7.1.3.2 Thermoelectricity as an Alternative Source of Renewable Energy

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

Institute of Fundamental Studies, Hantana Road, Kandy

Abstract

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). It has been known that when a conductor is subjected to a temperature gradient, there is a flow of electrons along the conductor. In order to get these electrons as a useful current through an external circuit, it is necessary to make two junctions with dissimilar material and maintain a temperature difference between the junctions. The phenomenon that generates electricity this way is called ***Seebeck effect.*** Output of a TEG depends on many factors. Effect of the cooling methods is discussed here. Our preliminary results indicate that active cooling produces a higher output; however, the overall efficiency is higher in passive cooling, when the energy used in the active cooling process is considered.

Introduction

Today, energy issues are controlling the political as well as the economical trends of the world. In recent years, unprecedented number of researchers is turning their attention towards energy related fields. More and more attention is paid to improve energy efficiencies of existing systems and to develop new sources renewable energy. One of the major drawbacks in energy conversions in general,

is the loss of energy, mostly as waste heat. A device that can convert at least a small fraction of this waste heat into a useful energy would increase the overall efficiency of the system by 'energy harvesting' or 'co-generation'. Thermoelectricity project at IFS was started with an intention to introduce one of the timely research fields that can improve the energy efficiency in aforementioned ways.

Modern TEGs can be used for electricity generation as well as for heating or cooling. They are used for energy harvesting, co-generation and Peltier cooling etc. They can also be used as thermovoltaic (TV) systems to generate electricity from solar energy or any other heat source. Production cost is much smaller for a TV system, compared to a photovoltaic (PV) sytem. Efficiency of a TEG depends on the physical factors such as geometry of the elements and cooling methods as well as the material used.

Method

At the preliminary stages of the research project at IFS, we focus on two physical factors: separation of hot and cold junctions and active vs passive cooling. We measured the output of a TEG device while using a small electric fan to cool the cold junctions, and same using passive cooling by air.

Results & Conclusions

Active cooling increases the output voltage significantly (Fig. 1). However, when the total energy budget is considered, active cooling falls behind, since a significant part of the energy generated is consumed in active cooling.

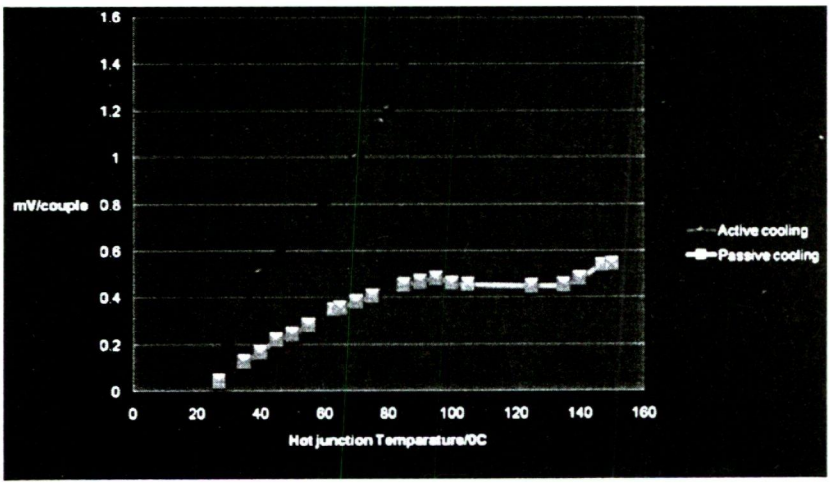


Fig. 1. Output of a simple Fe/Cu thermoelectric device under active and passive cooling conditions

Human Resource Development

Ph.D, M.Phil., M.Sc. students, undergraduate students; trained during 2012 with their affiliations; completed and passed out during 2012

1. Mr. P.D. Mahakumara from Atomic Energy Authority registered as a PhD student at University of Peradeniya with the joint supervision of Prof. C.B. Dissanayake and Dr. N.D. Subasinghe.
   Thesis title: Preliminary study on radon/thoron levels in Sri Lanka.

2. Mr. T.B. Nimalsiri registered for M.Phil degree at University of Peradeniya.
   Thesis title : Geothermal gradient of Sri Lanka with special reference to Highland-Vijayan boundary.

3. N.B. Suriyaarachchi registered for M.Phil degree at University of Peradeniya.
   Thesis title: Mapping geothermal resources in Sri Lanka using Magnetotelluric and other geophysical methods.

4. Ms. S.A. Samaranayake, from Rajarata University completed her BSc final year research project "Identify the competence of delineating subsurface extension of Eppawala apatite deposit using magnetic survey".

5. Mr. D.R. Charles was recruited as a research student/postgraduate student under a grant from the National Science Foundation.

6. Mr. P.L. Dharmapriya, MPhil student from University of Peradeniya is trained in petrological techniques (one year).

Collaborations

Institutes with MOUs in operation:
Mahidol University, Bangkok, Thailand
Atomic Energy Authority in Sri Lanka

Collaborating personnel

Prof. T. Iimoto, Tokyo University, Japan
Dr. T. Ishikawa, National Institute for Radiological Sciences, Japan
Mr. P.D. Mahakumara, Atomic Energy Authority of Sri Lanka
Mr. Nalin de Silva, Geological Survey and Mines Bureau
Dr. S. MalaviArachchi, University of Peradeniya

Resource personnel in workshops

Dr. N.D. Subasinghe contributed as a resource person in the 21st Workshop on Earth Science for Schools, 19-20 October 2012, in Jaffna, organised by the Geological Society of Sri Lanka (GSSL).

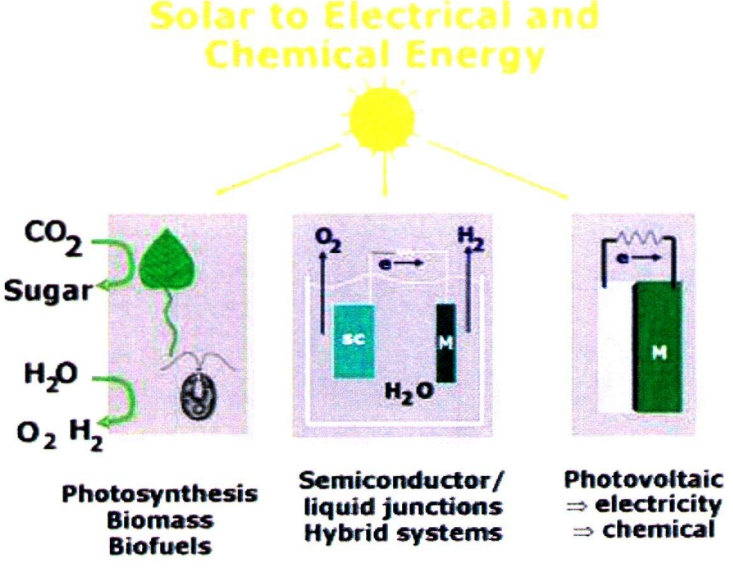
7.1.4 PHOTOCHEMISTRY

Harnessing Solar Energy by Artificial Photosynthesis as an Alternative Energy

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

Description of Project.

Fossil fuel is our main energy resource that is depleting rapidly. It has been estimated that the present fossil fuel reservoirs are sufficient for about 100 years. Apart from that, when fossil fuel is turned into useful energy through combustion, it often produces environmental pollutants that are harmful to human health and greenhouse gases that threaten the global climate [1]. As a result of these problems, finding alternative energy sources is vital for human beings. Intense research being conducted on alternative energy sources such as nuclear, wind, geothermal and solar energies. Out of the possible alternative energy resources, solar energy is found to be one of the prime targets to achieve the global energy requirements. Solar energy is widely available and have a benign effect on the environment and climate, making it an appealing alternative energy source. Solar driven production of environmentally clean electricity, hydrogen and other fuels, is considered as the only sustainable solution for global energy needs. The challenge is to raise its conversion efficiency by factors of five or ten which requires understanding the fundamental conversion phenomena at nanoscale.



In natural photosynthesis, carbon dioxide is converted to sugar by green plants by series of chemical reactions. Photosynthesis has long been studied to understand whether its natural mechanisms could be mimicked to apply to produce energy for human society. However, there are considerable challenges, with the first being to mimic the functioning of natural photosynthetic systems, the enzyme complex in the leaves of plants that splits water into hydrogen equivalents and oxygen via a catalyst comprising four manganese atoms along with some calcium.

As explained, by mimicking the natural photosynthesis, solar energy can be converted into electricity and chemical energy. The Photochemistry group at IFS is actively involving in investigation of conversion of solar energy into useful energy resources by artificial photosynthesis.

The Photochemistry group at IFS conducts research on conversion of solar energy into electricity, fuel and removal of water pollutants:

*Extending and adapting current photovoltaic technology, mainly dye-sensitized and polymer solar cells to generate electricity directly from solar radiation.
*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.
*Chemical, Electrochemical and Photochemical methods for the purification of water.

Photochemistry group members

Research Assistants: J. Akilavasan (Working on DSSC based on 1-D nanostructure), K.T. Wijeratne (Working on DSSC & hydrogen production), S.M. Wasana(Working on Water purification), A. Manjceevan (Working on DSSC based on Q-dot), D. Darmawickrame (Working on hydrogen production -Volunteer Research Assistant)
Senior Staff Technical Officer: D. Aluthpatabedi (Working on Water purification techniques)

Research summaries: The main long-term goal of the project is to find a feasible solution to energy crisis. Objective of the project is to investigate and research on alternative energy resources. Photochemistry project involves mainly in the field of renewable energy research and the project focused its research on development of new materials for photoconversion of solar energy into chemical and electrical energies. The Photochemistry project also involves investigation of low cost purification methods for abatement of industrial pollutants by using sunlight.

7.1.4.1 Fabrication of dye-sensitized solar cells, Bulk Hetero Junction Solar cells and hybrid solar cells

J. Akilavasan, D. Aluthpatabedi, D. Darmawickrame, A.Manjceevan, S.M. Wasana, K.T. Wijeratne, J. Bandara

Photochemistry Project, Institute of Fundamental Studies, Kandy

Objective

conversion of solar energy into electrical energy
(a) Different solar cells are being fabricated to convert solar energy into electrical energy. Q-dots of PbS, CdSe, CdS, Cu_2O were investigated as light harvesting units on TiO_2 naotube films.

(b) TiO_2 and SnO_2 nanotube were synthesised to be used as electrode for solar cells.

Results

We have successfully fabricated thin TiO_2 and SnO_2 naotube films on conducting glass to be used as electrodes. On these nanotube films, Q-dots were deposited and tested for their solar cell performance. Furthermore, these electrodes were tested for dye-sensitised solar cells. Due to lack of characterization facilities at the institute, we have sent samples abroad for characterizations. We have published our findings in an international refereed SCI journal.
Publications: manuscripts submitted to SCI journals-02, manuscripts in preparation-03

7.1.4.2 Fabrication of tandem solar cells and development of photocatalytic systems for hydrogen production

J. Akilavasan, D. Aluthpatabedi, D. Darmawickrame, A.Manjceevan, S.M. Wasana, K.T. Wijeratne, J. Bandara

Photochemistry Project, Institute of Fundamental Studies, Kandy

Objective

Conversion of solar energy into chemical energy

Multiple band-gap solar cells are fabricated by a novel method. This new method can be used to fabricate tandem devices easily. Also thin-film photocatalysts (i.e. WO_3 and Cu_2O) were fabricated. These electrodes will be assembled in a tandem manner to fabricate a device for water splitting. A new project was initiated to fabricate a catalytic system that is active in IR region.

Results

We have successfully developed an IR active photocatalyst and the low temperature tandem cell fabrication method.
Publications: Manuscripts in preparation-01

7.1.4.3 To identify the cause of Rajarata kidney decease (special project on effect of Al and F on kidney disease) (completed the project)

J. Akilavasan, D. Aluthpatabedi, D. Darmawickrame, A.Manjceevan, S.M. Wasana, K.T. Wijeratne, J. Bandara

Photochemistry Project, Institute of Fundamental Studies, Kandy

Objective

1. 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.
2. To detect the effect of AlF_x compounds on Chronic Renal Failure (Rajarata Kidney Disease).
3. To develop an effective and economical method in order to reduce the Fluoride concentrations in drinking water up to the WHO standards.

Results

We have already done the water quality analysis of the Rajarata area and statistical analysis is being carried out. An animal trial was concluded and the results being analysed.
Publications: Manuscripts in preparation-02.

Publications - Total SCI publications since inception: 38 (1999-2012)
Total SCI publications in year 2011-2012: 05

Human Resource Development

Research Assistants registered for M.Phil.

1. J. Akilavasan, registered for M.Phil.
   Title of Thesis: Quantum dot sensitized solar cells based on titania nanotubes
2. K. Wijerathne, registered for M.Phil.
   Title of Thesis: 1-Dimentional SnO_2 and ZnO Nanocomposites for enhancing the power conversion efficiency of DSSC.
3. U.W. Pradeep, Registered for M.Phil.
   Title of Thesis: Bulk-Hetero Junction Solar cells
4. W. Wasana, Registered for M. Phil.
   Title of Thesis: Quality of drinking water in Rajarata area and the CKD disease
5. Gannoruwa, Registered for M.Phil.
   Title of Thesis: Conversion of solar energy into chemical energy through tandem solar cell.

Undergraduate students trained during 2012

Three undergraduate students from Uve-Wellassa university trained for three months.
Another undergraduate student from Institute of Chemistry conducted research on full-time basis.

7.2 ARTIFICIAL ENERGY AND APPLIED ELECTRONICS

Project Leader: Prof. Asiri Nanayakkara (*Research Professor and Team Leader*)

Brain computer interface and sinhala language based artificial intelligence

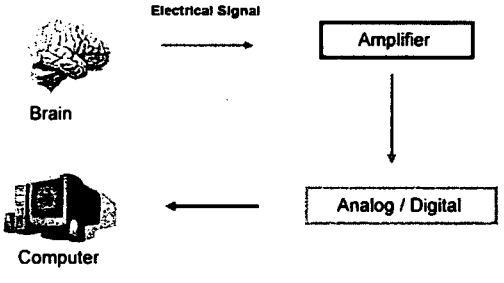
(a) Brain Computer Interface

Description

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 Amyothrophic Lateral Sclerosis (ALS), severe cerebral palsy, head trauma, and spinal injuries).

The Brain Computer Interface (BCI) project aims at building a high performance hardware and software system, which provides 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 equipments such as wheel chairs, televisions, etc and communicate using 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 that 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 the equipment needed for detection of other effects such as MEG is prohibitively expensive.



Although EEG systems are much cheaper, compared to MEG or fMRI machines, they are still quite expensive and therefore not affordable for most of the people in Sri Lanka. 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 system which could be used by severely physically disable people in Sri Lanka. This includes development of new techniques to extract thoughts from EEG signals and carrying out activities according to thoughts.

(b) Sinhala Language Based Artificial Intelligence

Description

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 disable person. For disable persons who can use their arms or hands, a keypad or an electronic glove is provided as input device 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).

Research Assistants: Dammika Wijethunga, Zahmeeth Sakkaff

7.2.1 BRAIN COMPUTER INTERFACE

Brief Introduction

BCI research group at Institute of Fundamental Studies (IFS) is mainly interested in constructing a BCI system based on Electroencephalography (EEG) which can be used by the paralysed 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 disable people in Sri Lanka. This includes development of new techniques to extract thoughts from EEG signals and carrying out activities according to thoughts.

Aims and objectives

Research and development work of BCI have been carried out during last two years in two main avenues: (1) Development of new methods and software system to recognise thoughts from individuals and control external devices according to recognised thoughts. This includes finding of 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 (2012)

During last few years we identified a very effective mental task called *Visual Arrow Movement (VAM)* which can be used with BCI. This year, in order to rule out the possibility that the good performance of VAM mental task is not due to eye movements, with the help of six subjects, signals from 20 EEG electrodes placed according to 10 – 20 system on the scalp were recorded and analyzed along with three Electrooculography (EOG) electrodes which were placed surrounding the left eye. In this experiment the EOG signals were recorded with the EOG/EMG amplifier which was designed and constructed in our BCI laboratory at IFS. The data collected in these trials was analyzed with various signal processing methods and we proved that the effectiveness of the VAM mental task is not due to EOG artefacts but due to the electrical activities in the brain which have altered the EEG signals.
Further, the EEG signals were analyzed using Common Spatial Patterns (CSP) to produce brain maps similar to what is shown in the Figure 1. This way we identified which area of the brain become active when the VAM mental tasks are performed. However, it is necessary to have a high resolution electro cap with at least 64 electrode to produce good CSP map. This has been planned for the next year. Further, we processed VAM data with CSP and used Linear Discriminant Analysis (LDA) as a classifier. This produced very good results which will be submitted for publication in 2013 after completing a comprehensive study.

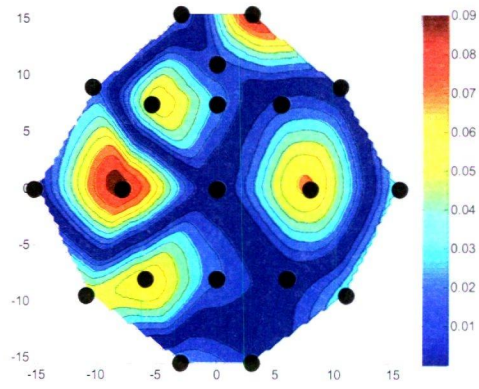
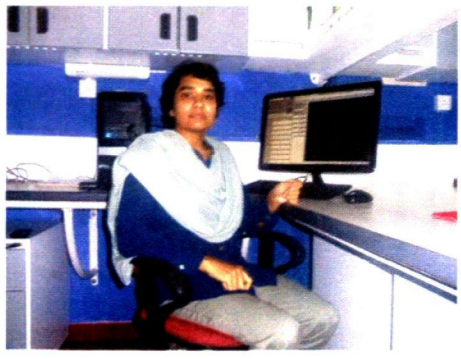


Fig. 1 Most important CSP pattern for distinguishing right arrow movement from down arrow movement of a single subject



Research Assistants: Dammika Wijethunga, Zahmeeth Sakkaff

7.2.2 SINHALA LANGUAGE BASED ARTIFICIAL INTELLIGENCE

Brief description

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 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.

Aims and 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 disable person. For disable persons who can use their arms or hands, a keypad or an electronic glove is provided as input devises 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 body.

Results (2012)

1. In order to produce high quality Sinhala Speech while keeping the low storage capacity of the sound database, a new sound unit was introduced and a mathematical method (Short-Time energy calculation) was applied to do necessary modifications for individual sound units when constructing words and sentences.
2. Additionally, the effect of one phoneme on other phoneme when combining those for generating a Diphone was studied with the Linear Predictive Coding (LPC) technique.
3. A software was developed for evaluating the new TTS System and here we mainly considered the Naturalness and Intelligibility.
4. Microcontroller based TTS system development was started. Here the basic embedded system was developed and presently several functions were implemented such as Sinhala fonts integration, Touch screen function as a input device, Secure Digital Card (SD card) interfacing and speech generation using pulse width modulation (PWM) method.

Human Resource Development

MPhil Student: Dammika Wijetunga, Department of Electrical Engineering, University of Peradeniya.

7.3 ENVIRONMENTAL AND EARTH SCIENCES

7.3.1 CHEMICAL AND ENVIRONMENTAL SYSTEMS MODELING

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

Decription of the Project

The research group of Chemical and Environmental Systems Modelling was started under Dr. Meththika Vithanage in latter half of 2009. Although groundwater serves as a good source for increasing demand, particularly in view of natural, anthropogenic pollution, climate change and sea level rise, it may be unfit for human consumption. Our research group works on understanding chemical processes in solid solution interface, assess, characterise, monitor water pollution, salt water intrusion and model these systems in order to find solutions for human benefit.

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

This project was started at the later part of the year 2009 and completed about 85 %. This research was aimed to understand the mechanisms of natural dissolution of heavy metal species such as Cr, Ni and Mn from serpentine soil. A model system was used to study Cr release based on different factors such as humic matter, Mn oxides etc. Mechanistic modelling of Ni removal from various clay materials was also studied in retaion to this project.

This research is funded by a grant from the International Foundation for Science (IFS, Sweden). Two abstracts have been published in international conferences in 2012. Research Assistant, Ms. RMAU Rajapaksha finished her research for her M.Phil Degree at the PGIS, UoP and left for PhD. Two SCI journal articles have been published by this research and the one in Geoderma Journal has been considered as one of the most downloaded articles in 2012.

Characteristics of landfill leachate and its treatment

This study was started in 2010 and ongoing. Characterisation of landfill leachate and soils from Gohagoda and Gampola solid waste dumps is undertaken. Spatial and temporal variations are under consideration with the support of geophysical techniques. At the same time, we develop and test different materials for leachate treatment including nano-materials.

Mr. SSRMDHR Wijesekara registered for M.Phil (2010) at PGIS is conducting the experiments. Several abstracts have been presented in several International and local conferences. Two undergraduate students from Sabaragamuwa University are conducting their undergraduate research projects while one Masters student from PGIS is carrying out her research related to this project.

Mechanistic modeling of fluoride adsorption on different materials

Fluoride is considered as one of the most common geogenic groundwater pollutant. This research was started in 2010 and about 40 % is completed. Our objective is to investigate characteristics of different materials including natural and synthesised nano materials suitable for fluoride removal, using experiments, modelling and spectroscopic techniques.

Two manuscripts have been published from this research in collaboration with Indian Institute of Technology, Madras and University of Peradeniya. Ms. RMAU Rajapaksha, Mr. SSRMDHR Wijesekara, Mr. IPL Jayarathna, Ms. A Madhave (PGIS), Dr. K. Mahatantila, Mr. Bootharaju, Prof. T.

Pradeep (IIT, Chennai), Prof. R. Weerasooriya and Dr. W.M.A.T. Bandara (University of Peradeniya) contributed to this research.

Biochar for environmental remediation

This research was started in 2012 and ongoing. The focus of this research is to investigate characteristics of different biochars produced by various waste resources in Sri Lanka under different conditions, for the soil and water pollution remediation using batch, column experiments, modelling and spectroscopic techniques. We collaborate with research groups at IFS (Microbial biotechnology unit, plant biology unit) and several international groups. Prof. D. Mohan (Jawaharlal Nehru University, India) and Prof. Y.S. Ok (Kangwon National University, Korea) contributed for this research.

One abstract was published from this research in International Biochar Initiative in May, 2012 in China. A new research assistant was appointed from September, 2012 for this research. Three volunteer research assistants who have been registered as MSc students at PGIS are currently working in Biochar project.

Cr(VI) remediation from soil and water using biological and chemical remediation methods

This research was started in 2012 in collaboration with the Microbial Biotechnology Unit at IFS in order to understand the toxicity of Cr(VI) from industrial waste waters in Sri Lanka and find an integrated solution through both biological and chemical techniques for its removal. As chemical methods, we use different materials to observe the adsorption and Cr stabilisation in soil.

Few abstracts have been published in local and international conferences based on the findings of this study. One volunteer student is conducting the research work for her MSc research project at PGIS.

Collaborative research projects

- Soil incubation studies on metal contaminated soils using advanced spectroscopic techniques: A research collaboration with the Kangwon National University, Korea (started).
- Biochar for the remediation of antibiotics from soil and waste waters: A research collaboration with the Kangwon National University, Korea (started).
- 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).
- International Water Management Institute and University of Jaffna: A research on N budgeting in Jaffna aquifer system (ongoing).

Research Assistants: Mr. I.P.L. Jayarathna, Ms. R.M.A.U. Rajapaksha, Mr. S.S.R.M.D.H.R Wijesekara, Ms. S.S. Mayakaduwa

Volunteers: Ms. M. Wijesundara (PGIS), Ms. A Thilakarathna (PGIS), Ms.U. Amanda (PGIS), Ms. N. Iwanthika (PGIS), Ms. Disna Eheliyagoda (Sabaragamuwa University of Sri Lanka), Ms. Sonia Mayakaduwa (Sabaragamuwa University of Sri Lanka)

Collaborators: Prof. Y.S. Ok (Kangwon National University, Korea)
Prof. K Dirdriksen and Prof. S. Stipp (Uni. of Copenhagen, Denmark)
Prof. T. Pradeep (Indian Institute of Technology, Chennai)
Prof. N. Priyantha, Prof. B.F.A Basnayake, Prof. R Weerasooriya,

Dr. A. Bandara, Dr. Pathmarajah (University of Peradeniya-UoP)
Dr. Christopher Oze (University of Canterbury, New Zealand)
Dr. Herath Manthrithilake (IWMI, Sri Lanka)
Dr. T. Mikunthan (University of Jaffna, Sri Lanka)

7.3.1.1. Natural attenuation of Cr(VI) in serpentine soils from Sri Lanka

Anushka Upamali Rajapaksha[1], Meththika Vithanage[1]*, Christopher Oze[2], and Y.S. Ok[3]

[1]Chemical and Environmental Systems Modeling Research Group, Institute of Fundamental Studies, Hantana Road, Kandy 20000, Sri Lanka,[2]Department of Geological Sciences, University of Canterbury, Christchurch, New Zealand, [3]Department of Biological Environment, Kangwon National University, Chuncheon, Korea

Weathering of ultramafic rocks produces soils containing high concentrations of Cr, Ni, Co and Mn. The oxidation of Cr(III) to form aqueous Cr(VI) is a potential hazard since Cr(VI) is highly toxic and can mix with groundwater. Therefore, we examined the formation of Cr(VI) in serpentine soils to identify their availability in the environment. The fractionation of Cr in the soil samples was investigated using sequential leaching techniques. The average concentration of total Cr in soil analysed from Ussangoda recorded around 11000 mg kg^{-1}. Cr(VI) concentration in soil recorded as 202 mg kg^{-1} (alkaline digestion followed by XAD7 resin extraction). Cr in the exchangeable fraction, was low (3.2 ± 0.2 mg kg^{-1}). Cr predominates in residual fraction and is organic matter bound (8,448 mg kg^{-1}, 83% and 693.1 mg kg^{-1}, 4.6% respectively). No detectable amount was low (3.2 ± 0.2 mg kg^{-1}). Cr predominates in residual fraction and is organic matter bound (8,448 mg kg^{-1}, 83% and 693.1 mg kg^{-1}, 4.6% respectively). No detectable amount of Cr(VI) is released from serpentine soils. Set of model experiments based on fuchsite and humic matter (HM) used to understand the attenuation of Cr(VI) formation showed fast initial rates of Cr(VI) production (1.52 × 10-4 mg kg^{-1} h^{-1} at pH 6) without HM in the system. However, with HM, Cr(VI) production decreases significantly (80%, 100 ppm HM). Cr(III) may have been released from the serpentine soil complexing with HM, which is more favorable in the environment, and that could potentially reduce the available Cr(III) to be oxidised to form toxic Cr(VI). Hence, HM may possibly play a major role in the natural attenuation of Cr(VI) formation of serpentine soils in Sri Lanka.

7.3.1.2 Characteristics of landfill leachate and its treatment

S.S.R.M.D.H.R. Wijesekara[1], Meththika Vithanage[1], K. Dideriksen[2], S.S. Mayakaduwa[2], U. Amanda[3], N. de Silva[4], B.F.A. Basnayake[5]

[1]Chemical and Environmental Systems Modelling Research Group, Institute of Fundamental Studies, Hantana Road, Kandy 20000, Sri Lanka, [2]Nano-science Center, University of Copenhagen, Denmark, [3]Post Graduate Institute of Science, University of Peradeniya, Peradeniya, [4]Geological Survey and Mines Bureau, Dehiwala, Sri Lanka, [5]Department of Agricultural Engineering, University of Peradeniya, Sri Lanka

Establishment of an appropriate landfill leachate treatment approach is a essential component to avoid serious environmental issues derived from open dumpsites which are most widely use solid waste management practice in the developing world. Therefore, physico-chemical characteristics of leachate generated from Gohagoda dumpsite, understanding their temporal and spatial variations, identification of subsurface canals and perched water bodies via geophysical methods were investigated aiming a proper treatment method. Efficacy of several nanomaterials; zero valent iron (NZVI) with different

novel stabilising agents, iron oxides (IONP), gibbsite (GNP) and silver (AgNP) were tested to treatment of landfill leachates. The nutrients nitrate and phosphate appeared to range between 1-765 mg/L and 2-258 mg/L respectively for leachate. Parameters such as solids and heavy metals also confirmed the pollution state. The resistivity study confirmed the leachate flow is confined to the near surface and no considerable separate/subsurface plume movement. The XRD and TEM confirmed all synthesized material were exclusively particulate nanomaterials and that observed unique properties which can be effectively used to remove pollutants (Figure 1). Among the tested nanomaterials from the batch experiments, NZVI and IONP were best and can be effectively use as environmental benign technology for landfill leachate treatment in Sri Lanka.

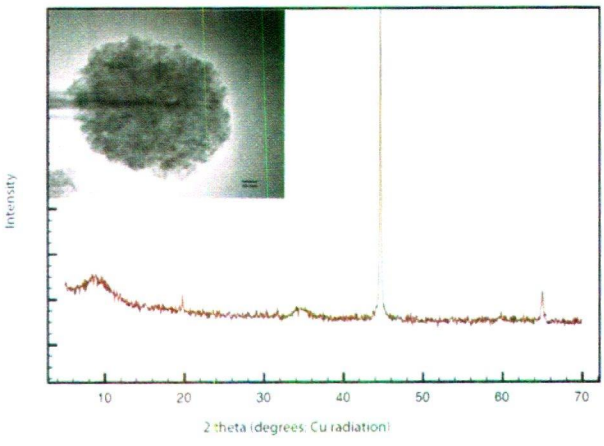


Figure 1: XRD patterns and TEM of NZVI. The scale bar of TEM image represents 10 nm in panel and XRD peaks are consistent of metallic iron. .

7.3.1.3 Synthesis and characterization of nanoparticles and molecular modelling

Lakmal Jayarathna[1], W.J. Ng[2], Athula Bandara[3], Meththika Vithanage[3], C.B. Dissanayake[3], R. Weerasooriya[4]

[1]Chemical and Environmental Systems Modelling Research Group, Institute of Fundamental Studies, Hantana Road, Kandy 20000, Sri Lanka, [2]Department of Civil and Environmental Engineering, Nangyang Technological University, Singapore 639798, Singapore, [3]Department of Chemistry, University of Peradeniya, Peradeniya 19000, Sri Lanka, [4]Department of Soil Science, Faculty of Agriculture, University of Peradeniya, Peradeniya 19000, Sri Lanka

Succinic acid attached γ-Fe_2O_3 nanoparticles were synthesized by co-precipitation method. Streptomycin was selected as model drug. Structure optimization and vibrational frequency calculations were done with Gaussian 03 software package (Figure 1). XRD and TEM results confirmed that particles are in 5 to 20 nm range and are well matched to "γ" phase of the iron oxide. FTIR spectral data confirmed that interaction between succinic acid and streptomycin on γ-Fe_2O_3 are bi-nuclear bi-dentate complexes. Drug releasing results show effective oral drug delivery system and releasing rate was very much higher under low pH conditions. The measured vibrational frequencies and bond distances are comparable with experimental observations.

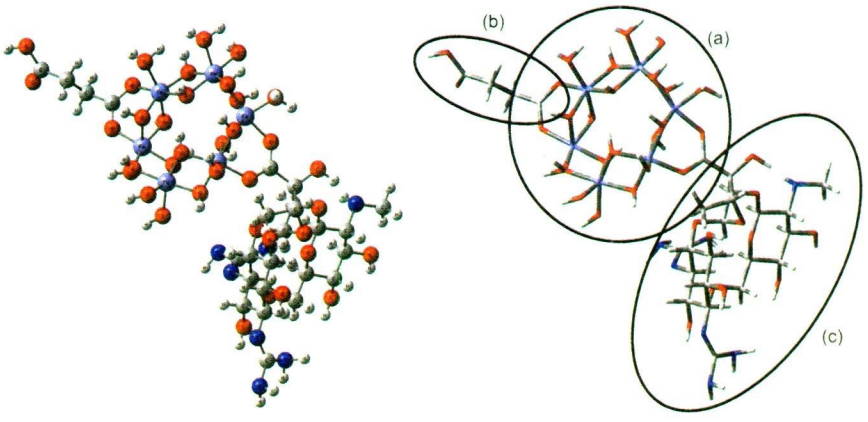


Figure 1. Optimised structure of succinic acid-Streptomycin-γ-Fe_2O_3 core-shell nanoparticle (a). γ -Fe_2O_3 cluster, (b). succinic acid, (c). streptomycin.

7.3.1.4 Removal of insecticide carbofuran from aqueous solutions using biochar made from waste biomaterials

Meththika Vithanage[1], A. Thilakarathna[2], N. Iwanthika[2], S.S. Mayakaduwa[1], I.P.L. Jayarathna[1]

[1]Chemical and Environmental Systems Modeling Research Group, Institute of Fundamental Studies, Hantana Road, Kandy 20000, Sri Lanka, [2]Post Graduate Institute of Science, University of Peradeniya, Peradeniya

Modern agriculture is always associated with pesticides, producing benefits as well as deleterious effects on the environment. Carbofuran (2, 3-dihydro-2, 2-dimethylbenzofuran-7-yl methylcarbamate) is a widely used insecticide in agricultural application and it may flow with runoff water to nearby water sources. Thus this study aims at preparing renewable, cheap solution for the removal of carbofuran from aqueous solutions using biochars from different waste materials such as tea waste (TWBC), rice husk (RHBC), coir pith and invasive plant biomass (*Lantana camara*). Biochar was produced from dried biomass at two different temperatures (300, 500 and 700 ^{0}C) and characterised. The obtained results showed that RHBC has higher carbofuran adsorption capacity than TWBC in 300 ^{0}C and 700 ^{0}C. Adsorption amounts at 700 ^{0}C and 300 ^{0}C RHBC were recorded as 49.44 % and 33.13 % respectively and those of TWBC were 12.25 % and 6.06 % respectively at pH 3. This may be due to the enlargement of micropores in surface of biochar at high temperatures and increased aromaticity. Experiments are ongoing.

7.3.1.5. Immobilisation and removal of Cr(VI) in polluted soil and water

Meththika Vithanage[1], D.M. Wijesundara[2], Anushka Upamali Rajapaksha[1], Namal Priyantha[3] and Yong Sik Ok[4]

[1]Chemical and Environmental Systems Modeling Research Group, Institute of Fundamental Studies, Hantana Road, Kandy 20000, Sri Lanka, [2]Post Graduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka, [3]Department of Chemistry, University of Peradeniya, Peradeniya, Sri Lanka, [4]Department of Biological Environment, Kangwon National University, Chuncheon, Korea

Objective of this research was to develop chemical and biological methods to remediate Cr concentrations in tannery waste and surrounding soils, and to screen possible amendments to

immobilise Cr in the soil. 120-day soil incubation experiment was conducted using tea waste (5%), tea waste biochar (TWBC) pyrolysed at 300 °C (5%), Fe oxide (1%) and Zr-Fe oxide (1%). The Cr concentrations in the tannery waste and soils were ranged from 1 to 513 mg/L and from 800 to 9,360 mg/kg, respectively. Sequential extraction revealed that Cr was mainly bound to organic matter, carbonate and residual fractions. The TWBC treatment reduced 90, 50 and 40% of DTPA, $CaCl_2$ and EDTA extractable Cr, respectively. However, TWBC treatment slightly reduced exchangeable Cr in soil compared to the control. Fe oxide treatment reduced exchangeable Cr by 90% but it had no considerable effect on other Cr fractions in the soil. Hence, combined use of TWBC and Fe oxide could be feasible to immobilise Cr in the tannery waste-contaminated soil.

Human Resource Development

Post graduate degrees obtained

Ms. RMAU Rajapaksha – M.Phil. 2012 (Post Graduate Institute of Science – PGIS)

Research Assistants registered for post graduate degrees

1. Mr. I.P.L. Jayarathna – Ph.D. Student (Post Graduate Institute of Science – PGIS)
2. Mr. Hasintha Wijesekera – M.Phil. Student (PGIS)

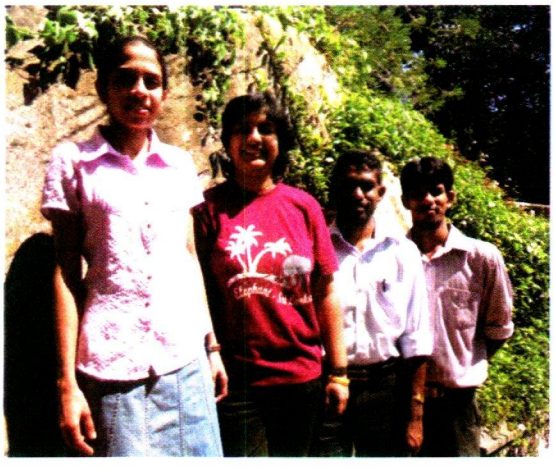
Part time research students

1. Ms. M Wijesundara – M.Sc. Student (Post Graduate Institute of Science – PGIS)
2. Ms. A Thilakarathna – M.Sc. Student (Post Graduate Institute of Science – PGIS)
3. Ms. N Iwanthika – M.Sc. Student (Post Graduate Institute of Science – PGIS)
4. Ms. U Amanda – M.Sc. Student (Post Graduate Institute of Science – PGIS)
5. Ms. DRMRDP Eheliyagoda – B.Sc. Student (Sabaragamuwa University of Sri Lanka)
6. Ms. SS Mayakaduwa – B.Sc. Student (Sabaragamuwa University of Sri Lanka)

Resource personnel in workshops

1. Dr. M Vithanage was invited as the guest speaker of the World Water Day at the Mahamaya College, Kandy, 2012.

2. Dr. M. Vithanage was invited as a resource person in the status verification workshop on Mercury organized by the Ministry of Environment, August, 2012.



7.3.2 ECOLOGY AND ENVIRONMENTAL BIOLOGY

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

Description of the project

Biodiversity surveys of Sri Lanka

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. The invertebrate fauna of our country remains largely unexplored, with most studies originating during the colonial period. Most studies on the flora of Sri Lanka are outdated. 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. However, this year we initiated a survey of the earwigs (Dermaptera) of Sri Lanka; they were last surveyed about 40 years ago.

Orchidaceae is one of the largest plant families in Sri Lanka, found in almost all terrestrial vegetation types and habitats. There are 188 orchid species belonging to 78 genera with one endemic genus and 55 endemic species in Sri Lanka. Forests of the lowland wet zone and the montane zone are rich in orchid diversity. Because of their beautiful flowers most orchids are ornamental plants of high economic value; sadly they are also threatened due to the same reason. Orchids are clearly an ideal target group for conservation. We are currently conducting a survey of the genera *Dendrobium* and *Bulbophyllum*. This is the first orchid survey undertaken since the Smithsonian Institution initiated floral project in the 1960s. All research projects commenced in or around June 2009. Three research assistants 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 Kelaniya, Sri Lanka; University of New Hampshire, USA; University of Arizona, USA; Zoologisches Forschungsmuseum Alexander Koenig, Germany).

Biodiversity of soil arthropods

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 is in preparation.

Research Assistants: Buddhika Perera, Harshani Sandamali
Senior Staff Technical Officer: Namal Atukorala

7.3.2.1 Comparative Surveys of Phytoplankton and Zooplankton in Sri Lankan Reservoirs

B. Perera[1], S.K. Yatigammana[2], S. A. Kulasooriya[1]

[1]Ecology and Environmental Biology Project, IFS, Kandy, [2]Department of Zoology, University of Peradeniya, Peradeniya

Phytoplankton and zooplankton, microscopic drifting plants and animals are vital components of the marine and freshwater aquatic food chains, and water systems. As planktons are well known biological indicators the presence, abundance and diversity of these organisms provide important information of environmental conditions and also can be used to predict past and future scenarios of the environment.

Sixty one freshwater reservoirs distributed in the dry, wet and intermediate zones of Sri Lanka were sampled (Fig 1)

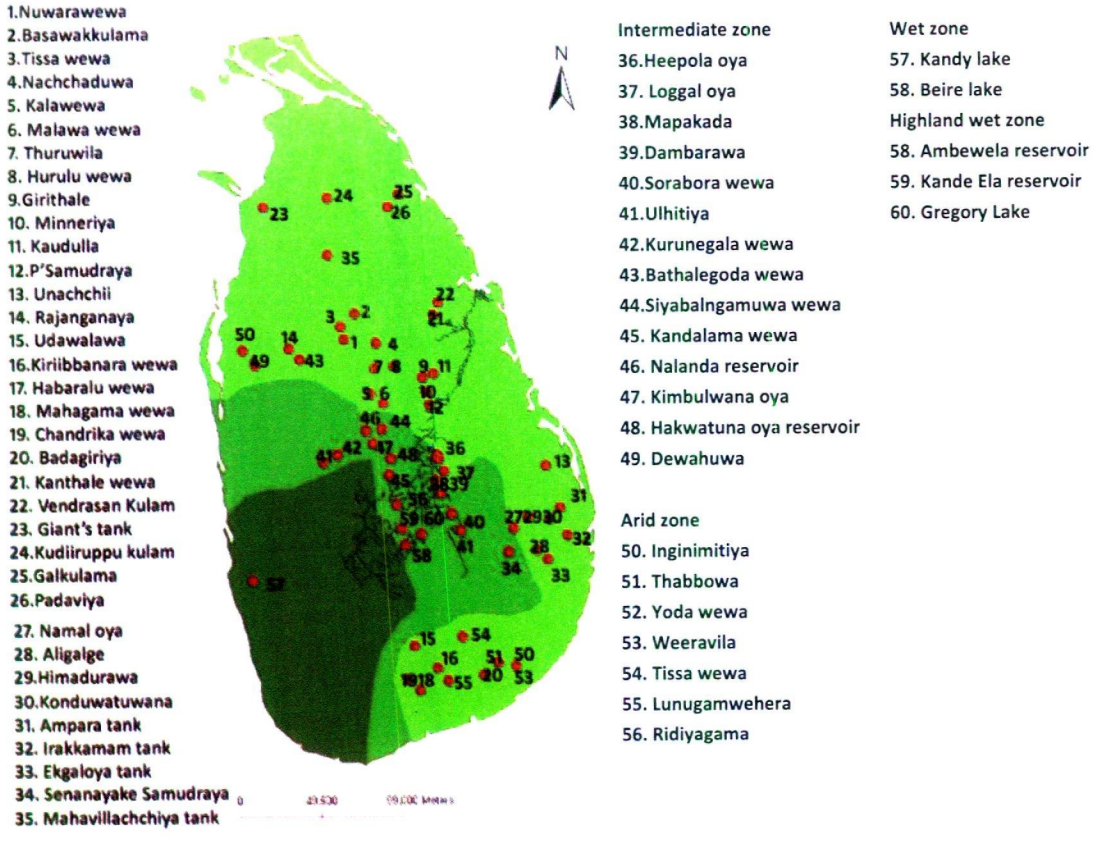


Figure 01 : The map which shows the distribution of the sampling sites through out Sri Lanka.

Altogether a total of 123 plankton genera were recorded. Among them sixty nine genera were phytoplanktons while 29 genera were zooplanktons. However, 27 species remained unidentified. Out of 87 genera identified, 24 belonged to the phylum Chlorophyta which can be considered as the most diverse group in terms of distribution. Three genera belonging to the phylum Euglenophyta, 03 genera belonging to Xanthophyceae, 19 genera belonging to Cyanophyta, 17 genera belonging to Bacillariophyceae & 03 species belonging to Dinophyceae. With reference to the distribution of cyanobacterial species highest diversity was observed in the Anuradhapura district with all 19 genera being present in those reservoirs.). Toxin producing Cyanobacteria species such as

Cylindrospermopsis raciborskii, *Microcystis* sp. and the Dinoflagellate *Peridinium* sp. were recorded in the dry zone reservoirs in relatively high abundance. The toxin producing *Cylindrospermopsis raciborskii* in Lake Gregory of the Nuwara Eliya District has not been reported earlier. Among the zooplantoktons, Phylum Cladocera was the dominant group while Phylum Ostracoda was rare. The number of genera identified belonging to different zooplankton groups were as follows: 07 genera of Rotifera, 12 genera of Cladocera, 02 genera of Ostracoda & 04 genera of Copepoda. Among the zooplankton, cladocerans were the dominant group. All the observed planktons were photo documented and will be used for the preparation of a guide for the identification of planktons. While cyanobacteria were recorded from all the reservoirs sampled, all the different species observed were present in the Anuradhapura district indicating a wide diversity of cyanobacteria in this area.

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

Harshani Sandamali and Suresh P. Benjamin

Ecology and Environemental Biology Project, IFS, 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*. 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.
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. Vegetative and floral morphometric data will be analyzed using the delta software package. We also plan to characterize the species using facilities available at the modern molecular biology laboratory of the Ecology and Environmental Biology project at the Institute of Fundamental Studies. We have extracted DNA from our samples and are in the process of PCR amplification.

7.3.3 ENVIRONMENTAL ENGINEERING/ELECTROCHEMISTRY

Project Leader: Dr. K.G.N. Nanayakkara (*Research Fellow*)

Description of Project

In Environmental Engineering/ Electrochemistry research group, we are mainly carrying out research on understanding the fundamentals of pollution removal processes. The acquired knowledge is then applied in developing engineering applications. Electrochemistry is used as a process in treatment (e.g. through electrochemical pollution removal) as well as a tool in process development (e.g. investigating reactions and material properties). Our main research work is currently on developing electrochemical technologies to treat polluted water.

Water pollution is an environmental problem which creates health, economical, and ecological impacts everywhere in the world. List of water pollutants is growing and need of advanced treatment technologies is becoming a necessity. Compared to the other technologies, electrochemical technologies have certain advantages. For instance, anodic reactions produce a series of oxidants in-situ. Therefore, no chemical storage or handling is required. Besides, direct oxidation of contaminants at the anode also possible. Thus, the potential of organic contaminant removal at the anode is high. Cathodic reduction provides an excellent environment for pollutant removal (e.g. heavy metals). As such, we are working on developing novel materials and processes for electrochemical water treatment technologies.

Three projects were started under the above theme in September- November 2011. They are as follows.

(a) Anodic oxidation of phenol in contaminated water on dimensionally stable anode (IFS funded)
(b) Development of electrochemical technologies to remove organic and heavy metal pollutants present in pesticides (NRC funded; grant # 11-054)
(c) Development of an electrochemical technology to remove nitrate from contaminated groundwater (NSF funded; grant # RG/2011/BS/01)

Project photos

Research Assistants: Ms. Pavithra Bhakthi Jayathilake, Ms. Chandima Weerakkody (NRC funded), Ms. Gayani Chathurika Pathiraja (NRC funded)
Technical Assistant: Ms. Pratheeksha Wimansi Abeygunawardhana (NSF funded)
Senior Staff Technical Officer: Mr. W.G. Jayasekara
Volunteer: Ms. Lasangi Danapala (Pre-University Research Assistant)

7.3.3.1 Anodic Oxidation of Phenol in Contaminated Water on Dimensionally Stable Anode

H.A.P.P.B.Jayathilake[1], W.M.A.T. Bandara[2], W.G. Jayasekara[1], K.G. N. Nanayakkara[1,3]

[1] Environmental Engineering/Electrochemistry Project, Institute of Fundamental Studies, Hantana Road, Kandy, [2]Department of Chemistry, Faculty of Science, University of Peradeniya, [3]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya

Abstract

Phenol is one of the well-known industrial wastewater pollutants. Electrochemical degradation of phenolic compounds through anodic oxidation has been studied and reported in scientific literature [1]. However, only few studies have been done on probing mechanism(s) behind the anodic oxidation of phenol [2]. Developing mixed-metal (or metal oxide) electrodes (anode material) has been reported in literature [3]. Nonetheless, most of the investigations are limited to researching on comparing few different types of electrodes. Little attention is paid on optimizing anode material. Therefore, this project addresses the above limitations by probing mechanisms of electrochemical degradation of phenol and by developing optimized anode material for the electrochemical degradation of phenol.

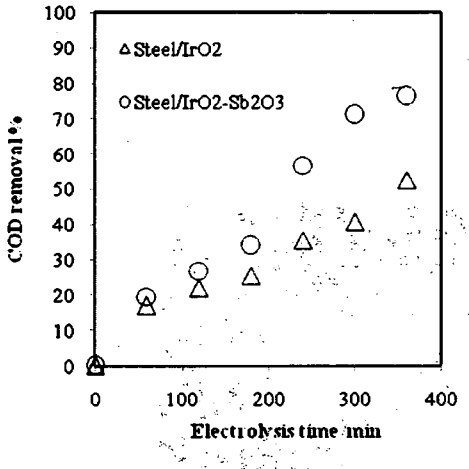


Fig. 1: Mineralisation of phenol

Over 75% mineralisation was achieved on developed anode (Fig. 1). Mechanism(s) study conducted using experimental and theoretical investigations revealed that hydroxyl radical plays an important role in oxidation.

Optimisation of the developed anode is yet to be conducted.

References

1. Wei, J., Zhu, X., Ni, J., (2011). Electrochemical oxidation of phenol at boron-doped diamond electrode in pulse current mode, Electrochimica acta, 56, 5310-5315.
2. Mahmoud, S.S., Ahmed, M.M., (2009). Electrocatalytic oxidation of phenol using Ni-Al2O3 composite-coating electrodes, Journal of alloys and compounds, 477, 570-575.
3. Zheng, Y., Su, W., Chen, S., Wu, X., Chen, X., (2011). Ti/SnO2-Sb2O5-RuO2/α-PbO2/β- PbO2 electrodes for pollutants degradation, Chemical engineering journal, 174, 304-309.

7.3.3.2 Development of Electrochemical Technologies to Remove Organic and Heavy Metal Pollutants Present in Pesticides

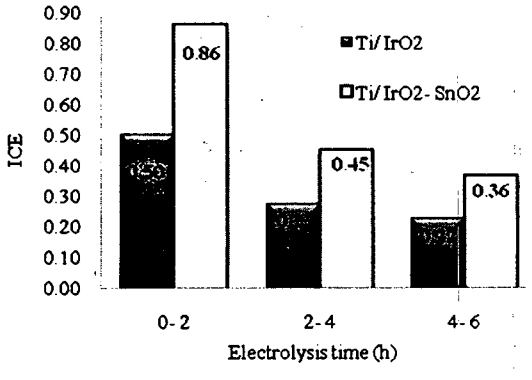
C. Weerakkody[1], G.C. Pathiraja[1], D.G.G.P. Karunarathne[2], K.B.S.N. Jinadasa[3], A. Wijesinghe[4], K.G. N. Nanayakkara[1,3]

[1] Environmental Engineering/Electrochemistry Project, Institute of Fundamental Studies, Hantana Road, Kandy, [2]Department of Chemical Engineering, Faculty of Engineering, University of Peradeniya, [3]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, [4]Department of Science and Technology, Uva Wellassa University

Abstract

It has been found that the agro-chemicals enter the water bodies either through agricultural runoffs or through industrial effluents where formulation and packaging of pesticides are carried out. These effluents may carry organic and inorganic contaminants (e.g. heavy metals) to surface and groundwater sources [1]. This research addresses the abovementioned problem by developing sustainable technologies based on electrochemical reactions to treat pesticide contaminated water streams. Possibilities of simultaneous removal of organics and heavy metal(s) in a single reactor will be investigated.

Two anodes were successfully developed and used in removing chlorpyrifos from water. Considerably high current efficiencies were found in both anodes (Fig. 2). Anode optimization has been carried out. Mechanisms involved in electrochemical oxidation of chlorpyrifos have been studied.



A methodology was successfully developed to prepare the cathode of the cell. Optimisation work has been initiated.

Fig. 2: Change in current efficiencies

References

1. J.M.R.S. Bandara, H.V.P. Wijewardena, J. Liyanage, M.A.Upul, J.M.U.A.Bandara, (2010). Chronic renal failure in Sri Lanka caused by elevated dietary cadmium: Trojan horse of the green revolution, *Toxicol. Lett.198*, 33-39.

7.3.3.3 Development of an Electrochemical Technology to Remove Nitrate from Contaminated Groundwater

P.W. Abeygunawardhana[1], J.P. Pathmasiri[1], M. Vithanage[1], K.B.S.N. Jinadasa[2], K.G. N. Nanayakkara[1,2]

[1] Environmental Engineering/Electrochemistry Project, Institute of Fundamental Studies, Hantana Road, Kandy, [2]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya

Abstract

Electrochemical denitrification has been reported in literature [1]. However, little attention is paid on developing and optimising novel electrode materials. In addition, the oxidation of the reduction by-products mainly depends on the availability of chloride in water. As such, this research focuses on developing and optimising novel electrode materials, considering the factors pertaining to efficient nitrate removal. Enhancing the oxidation of by-products in chloride-free electrolyte is investigated.
In this research, cathode material was developed using a coating layer applied on inert substrate material. About 70% removal of nitrate was achieved without optimisation of the electrode. Optimisation of cathode material has been carried out considering effective nitrate removal and electro-active surface area (Fig. 3). Anode material selection was also carried out. Rare-metal oxide coated anode material was found to be performing well in chloride-free electrolyte. Work on optimisation of anode material has been initiated.

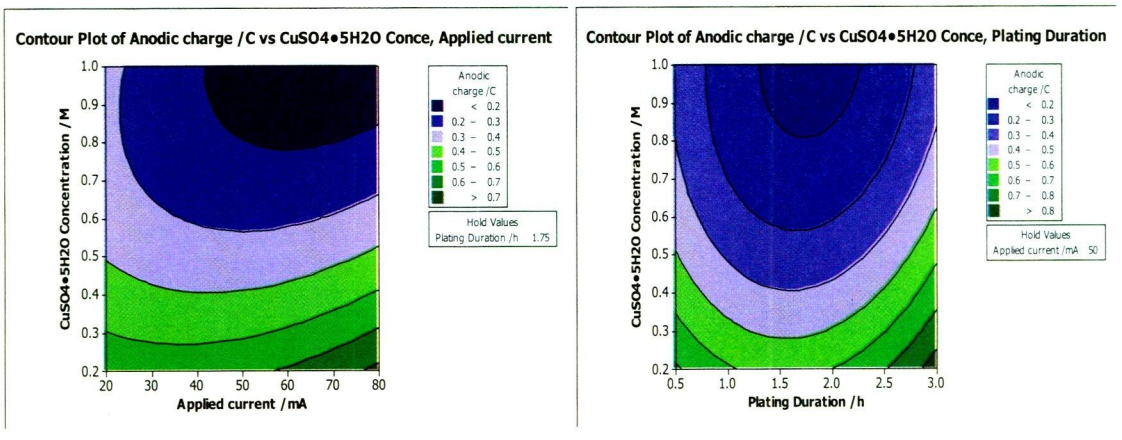


Fig. 3: Contour plots related to the optimization of cathode material

References

1. D. Reyter, D. Belanger, L. Roue, (2010). Nitrate removal by a paired electrolysis on copper and Ti/IrO_2 coupled electrodes-Influence of the anode/cathode surface area ratio, *Water res. 44*, 1918-1926.

Human Resource Development

Students registered for M.Phil degree at Post Graduate Institute of Science

1. H.A.P. Pavithra Bhakthi Jayathilake, IFS Research Assistant
   Tentative title of thesis: Anodic oxidation of phenol in contaminated water on dimensionally stable anode.
2. Chandima Weerakkody (NRC Research Assistant)

Tentative title of thesis: Development and optimization of cathode material for the reduction of heavy metals in pesticides.

3. Gayani Chathurika Pathiraja(NRC Research Assistant).
   Tentative title of thesis: Development and optimization of anode material for oxidation of organic components in pesticides.

Students registered for M.Sc degree at Post Graduate Institute of Science

Pratheeksha Wimansi Abeygunawardhana, (NSF Technical Assistant)
Tentative title of thesis: Development of a novel electrode material to remove nitrate from contaminated ground water

Pre-University Research Assistant

Lasangi Danapala, Worked as a volunteer

7.3.4 NANOTECHNOLOGY

7.3.4.1 GREEN NANOTECHNOLOGY

Project leader: Prof. C.B. Dissanayake *(Director, IFS)*

Description of the project

When the physicist and Nobel laureate Richard Feynman challenged the science community to think small in his 1959 lecture 'There's Plenty of Room at the Bottom', he planted the seeds of a new era in science and technology. Nanotechnology, which is about controlling matter at near atomic scales to produce unique or enhanced materials, products and devices, is now maturing rapidly. Yet concerns have been raised that the very properties of nano-structured materials that make them so attractive could potentially lead to unforeseen health or environmental hazards. For example, if nanoparticles are deployed in electronics and deemed safe because they are closely bound within the matrix of a circuit board, what happens if they are released into the environment when the circuit board is destroyed or disposed of? What if it catches fire? And what about waste disposal and nanotech-enabled manufacturing plants?

The IFS Green Nanotechnology Research Program has been started to design environmentally safe nanomaterials in compliance with green chemistry principles. During the period of review, our research group has actively been involved in utilizing iron based material such as zero valent iron, iron oxides and pyrite for pollution control. Research will also include an examination of the transport and fate of nano-materials in aqueous environments examining the elements of nano-material surface chemistry and reactivity that affect toxicity and mobility, and performing life cycle assessments of environmental impact and risk associated with nano-materials production, use, and disposal.

Research Staff: Rohan Weerasooriya Research Professor, IFS (2012)
A. Bandara, Dept of Chemistry University of Peradeniya
M. Mahakehelwala, Chemist, Greater Kandy Water Supply Scheme, Kandy
Ajith Herath, Head/ Dept of Applied Science, Rajarata University

Research Students: Atula A. Tusitha, Uwa Wellassa University
Deepika Perera, Rajarata University
Chamali Narangoda, Institute of Chemistry
Vidumin Dahanayake, Institute of Chemistry

7.3.4.2 Novel Fenton Reagent from Nano Pyrite – A Green Chemistry Application

Rohan Weerasooriya[1], Atula Bandara[2] and C.B. Dissanayake[3]

[1]Dept of Soil Science, University of Peradeniya, [2]Dept of Chemistry, University of Peradeniya and [3]Institute of Fundamental Studies, Kandy

Pyrite, FeS_2 (space group Pa $\bar{3}$) is an amazing ubiquitous mineral in nature. It occurs in different structures. Pyrite is a Greek word for 'fire' due to the sparks that result when pyrite is struck against steel. It sometimes is called Fool's gold as miners mistake it for gold, though small quantities of actual gold are sometimes found. Pyrite resembles gold in color and luster but its other physical properties are very different. Pyrite is harder, less dense, and more brittle. Pyrite has been used for ornamental pieces and in jewellery for thousands of years. Examples of this can be seen from the ancient civilizations of the Greeks, Romans and Incas. The Incas in South America had used large, polished

slabs of the mineral as magnificent mirrors. The North American Indians also used pyrite as amulets. Pyrite often associated as an impurity in vein Sri Lankan graphite. Removal of pyrite from the graphite is a challenge faced. Pyrite yields environmentally benign products upon oxidation. Surface chemistry of pyrite is fascinating. Pyrite offers dual characteristic; hydrophobic and hydrophilic behavior.

Although exact mechanistic steps are unresolved to date, our research group has evidenced water splitting upon pyrite mediation. The hypothesis in much of this recent work is focused on reactive oxygen species that form via the interaction of pyrite with aqueous solutions. Therefore, hydroxyl radicals and hydrogen peroxide spontaneously form when pyrite is exposed to water. The postulated reactions mentioned are given below:

$$Fe^{2+} + O_2 \rightarrow Fe^{3+} + \left(O_2^{\bullet}\right)^-$$
$$Fe^{2+} + \left(O_2^{\bullet}\right)^- + 2H^+ \rightarrow Fe^{3+} + H_2O_2$$
$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^{\bullet} + OH^-$$

The hydroxyl radical is a non-specific oxidant that reacts with most recalcitrant organic pollutants in the environment. This finding is utilized in designing a novel Fenton's reagent to detoxify harmful organic pollutants present in water. In essence, the process is very attractive in that it no longer needs expensive chemicals like H_2O_2 or ferrous sulfate. A model treatment plant which was designed based on this technology will represent Sri Lanka in Sweden for the Stockholm Junior Water Award 2012 by a group of young talented students from Dharmaraja College, Kandy (*B.M. Rankothge, K.C. Jayakody, and H.A.H.I. Perera*). The project received funding from the National Research Council of Sri Lanka (Grant No: NRC 06-017).

7.3.4.3 Fabrication of Nano Hydroxy iron Oxides for Drug Delivery

L. Jayarathne[1], A. Bandara[2], M. Vithanage[1], R. Weerasooriya[3], N. Ng[4]

[1]Institute of Fundamental Studies, Kandy, [2]Dept of Chemistry, University of Peradeniya, [3]Dept of Soil Science, University of Peradeniya, [4]National University of Singapore, Singapore

Core–shell nano-structures were synthesized by adsorbing succinic acid on γ-Fe_2O_3 nanoparticles (hereafter referred to as core–shell nanoparticles or core–shells). Streptomycin was chosen as a model drug to attach on γ-Fe_2O_3 core–shells. Vibration spectroscopic data confirmed the specific adsorption of organic ligands (i.e., succinic acid or streptomycin) onto γ-Fe_2O_3 via bi-dentate, bi-nuclear complex. Possible molecular configurations between organic ligands and γ-Fe_2O_3 were examined by density functional theory (DFT) using $Fe_6(OH)_{18}(H_2O)_6$ ring cluster. The measured vibration frequencies and bond distances (i.e., Fe O Fe, Fe O_w, and Fe OH units) of the optimized γ-Fe_2O_3 cluster matched well with the calculations.

7.3.4.4 Development of Metal ion Buffers from Nano-kaolinite for in-situ Calibration of Ion Selective Electrodes

Rohan Weerasooriya[1], Madubhasini Makehelwala[2]

[1]Dept of Soil Science University of Peradeniya and [2]National Water Supplies and Drainage Board Kandy

Metal ions speciate in natural water. Bioavailability and toxicity of trace metals depend on the chemical speciation of metals in the matrix. Out of the wide array of metal ion species, only free form,

in the case of copper free copper aqua ligand, $Cu(H_2O)_6^{2+}$ is biologically active. However most of the experimental methods detect the total metal ions concentration, not the different chemical species; to date there are no good experimental methods to detect free metal ion activity. Cupric ion selective electrodes (CuISEs), can be valuable probes in the determination of free metal ion activity. However if the manufacturer recommended procedure is followed, the lowest limit that can be detected by a CuISE is restricted to 10^{-6} M. This is not an inherent limitation in the ion selective electrode itself, but this problem resulted due to the use of unbuffered metal ion standards during the calibration. The scientists of our research group use copper/ ethylenediamine/ nano-kaolinite buffers, i.e. en/copper ions to overcome this situation. We showed that the linear range of the Cu(II) ion selective electrode was extended even up to 10^{-12}M, i.e. pCu = 12. Once these metal buffer systems are fully operational, the free metal ion concentrations in natural water samples can be measured in situ at a fraction of cost.

Human Resources Development

M.Phil. Degree: M. Makehelwala
Tentative title: Adsorptive degradation of Cl-phenols by pyrite
PGIS, University of Peradeniya (dissertation submitted – presently under review)

PhD Degree: L. Jayaratne
Tentative title: Synthesis and characterization of γ-Fe_2O_3 nano particles
PGIS, University of Peradeniya (dissertation submitted)

7.3.5 WATER QUALITY IMPROVEMENTS IN THE DRY ZONE AREAS OF SRI LANKA

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

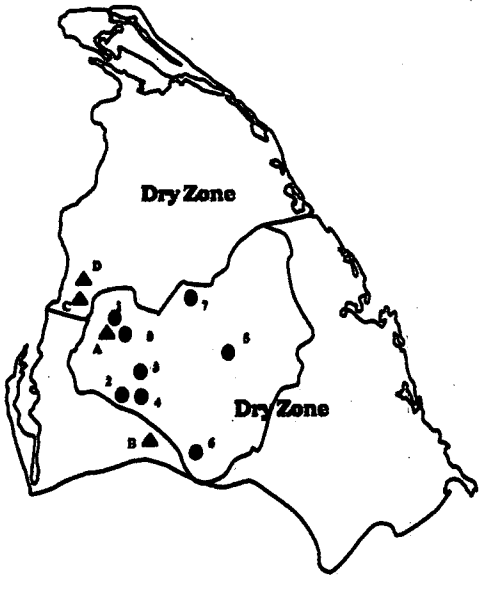
Description

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 to the rural communities in 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 by the Institute of Fundamental Studies. 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 is 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 introducing an 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). This project was further extended in 2012 by establishing 08 Electrocoagulation Water Purification Plants (200 liters/hour) in Anuradhapura district from the funds received from the Ministry of Technology and Research. Another two water purification units were established in Vavuniya district from the funds received form Non-Government Organizations. This project has gained recognition and the Ministry of water supply established 05 such plants in these areas during 2012. All these work were done in collaboration with Spectra Industries Lanka (Pvt) Ltd, Kurunegala.

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

Map of Water Purification Plants :



Funds from Private sector

A - Asokamalagama, Nochchciyagama
B - Nikawewa, Kurunegala
C - 2 Acre farm, Cheddikulam
D - 400 Acre farm, Ulukkulama

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

Figure 1 : Electrocoagulation Unit

Figure 2 : On the Job Training

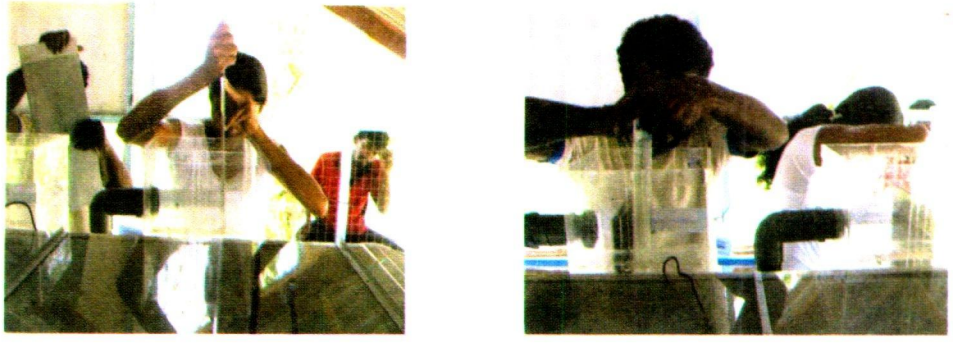


Figure 3 : Fixing Plates to the Reactors

Figure 4 : Collecting Purified Water

7.3.6 BIODIVERSITY AND CONSERVATION

7.3.6.1 PRIMATE BIOLOGY AND CONSERVATION

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

Description of the project

This project concerns observational studies of monkeys (primates) in their natural forest habitat 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.

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 to the Biodiversity Secretariat and Ministry of Environment's recent "National Red List 2012" of Sri Lankan mammals. 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 attracted visitors to the country.

Research Coordinator: Sunil Gunathilake
Senior Research Assistant: Chameera Pathirathne
Research Assistant: Sunil Rathanayake
Visiting Intern: Melissa Felder

Collaborators

- Prof. R. P. V. Jayanthe Rajapakse, Professor of Parasitology and Head of the Department of Pathobiology, University of Peradeniya, Peradeniya.
- Dr. Ashoka Dangolla, Faculty of Veterinary Medicine and Animal Health, University of Peradeniya.

- Professor Peter Nuernberg, Cologne Center for Genomics CCG, University of Cologne, Germany

Human Resource Development

In collaboration with the Department of Education, we delivered 6 programs to about 300 students in 2012 in order to promote environmental awareness and nature education among schools in the Polonnaruwa District.

- Venue at Smithsonian Field Research Station forest plot as well as Royal College (Polonnaruwa) Nature Center; about 50 students and teachers per session on: 23 June, 7 July, 28 July, 15 August, 26 September, 29 September.
- Practical and lecture presentation by project staff and BBC film crew "How to Produce a Nature Documentary" Royal College (Polonnaruwa), 7 September 2012, about 150 students and teachers.

Conferences and Lectures

- W. Dittus, 15 March 2012. Sri Lanka Wildlife and Nature Protection Society, "Problems with Monkeys: Myths and Solutions"
- W. Dittus, 20 October 2012. Sri Lanka Institute of National Tour Guides and Lecturers. "Primates of Sri Lanka" and "Monkey Educational Tours and Programs"

7.4 FOOD SCIENCE AND NUTRITION

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

Description of the Project

This project commenced activities from January 2011. The aim of this project is to uplift the nutritional status of people in Sri Lanka. The main focus is to find solutions through naturally available resources 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 food nutrition and well being. At present Sri Lanka is facing two different nutritional problems related to income distribution and educational back ground. In the low income groups there is malnutrition among pregnant mothers and children. On the other hand people with medium to high income particularly living in the urban areas suffer from diet related diseases such as obesity, diabetes, hypercholesterolemia etc. For the malnutrition problem among pregnant mothers and children, the best solution could be found with already available foods with required nutritional properties. In this regard we have chosen Murunga leaves (*Moringa Oleifera)* and a micro alga (*Spirulina platensis*) as potential sources with required nutritional properties to address malnutrition problems specially associated with protein and micronutrient deficiencies. We have analyzed the micro nutrient and protein contents of *Moringa* leaves collected from eight different districts of Sri Lanka and found that *Moringa* leaves can be used as sources of protein and micronutrients for malnourished people in Sri Lanka. Further, semi-mass cultured *Spirulina* at the IFS was found to be a very good source of protein, micronutrients and antioxidants.

Another study was conducted to investigate the hypocholestaerolemic ability of commonly consumed cowpea cultivars in Sri Lanka. From the results it was observed that Bombay and MI35 cowpea cultivars significantly reduced serum cholesterol in rats compared to control diets used in the study. This experiment was conducted in collaboration with department of Animal Science, Faculty of Agriculture, University of Peradeniya.

Research expertise: Prof. S.A. Kulasooriya
Research Assistants: Ms. O.S.Perera, Mr. Nishantha Wijesuriya (NSF grant)
Senior Staff Technical Officer: Ms.Iranaganie Thumpela

Murunga leaf powder

Culturing *Spirulina platensis*

7.4.1 Cowpea (*Vigna unguiculata* L. Walp) Incorporated experimental diets modulate the serum lipid profile and caecal microflora in Wistar rats(*Rattus norvegicus*)

Itan L. Perera[2], Lakmini Waduruarachchi[3], Oshini Perera[1], N Wijesuriya[1], Barana C. Jayawardana[2], Janak K. Vidanarachchi[2] and Ruvini Liyanage[1]

[1] Food Science and Nutrition Project, Institute of Fundamental Studies, Hanthana Road, Kandy, [2] Department of Animal Science, University of Peradeniya, [3]Department of Agricultural Systems, Rajarata Univesity of Sri Lanka

Introduction

Cowpea (*Vigna unguiculata* L. Walp) is a major grain legume in Sri Lanka. Whole cowpea seeds provide proteins, important vitamins, dietary fiber, phyto-nutrients including antioxidants besides carbohydrates, minerals and trace elements (Moses, 2006). In recent years, much attention has been paid to dietary interventions that lower plasma cholesterol concentration among humans as a tool to prevent and treat coronary heart diseases (Frota *et al.*, 2008). This research study was carried out to investigate the effects of four different cowpea cultivars on the serum lipids and caecum bacterial population in Wistar rats fed a high fat diet.

Materials and Methods

Seven weeks old 36 male Wistar rats were randomly divided into 6 groups with 6 replicates. They were housed individually in metal cages. After 7 days of acclimatization period, experimental diets were offered *ad libitum*. Experimental diets were prepared according to the AIN-93G semi-purified rodent diet (Reeves *et al.*, 1991) and 23% lard was added to obtain the HFD (High fat diet). Treatments were; HFD with 20% whey powder (CNF), HFD with 20% Waruni cowpea powder (WAF), HFD with 20% Bombay cowpea powder (BBF), HFD with 20% Dawala cowpea powder (DAF), HFD with 20% MI35 cowpea powder (MIF) and NFD (non fat diet) with 20% whey powder (CNN). Body weight and food consumption were recorded weekly. Individual fecal matter was collected and weighed during the final week. All rats were sacrificed after 6 weeks and blood was quickly collected under anesthesia. Liver, caecum, kidney fat and abdominal fat were dissected and weighed. Lactobacilli, total anaerobes and Coliforms bacteria in cecal content were enumerated. Serum lipid profile was analyzed using assay kits for TDX system and liver antioxidant capacity was measured (AOAC, 2005). Data were analyzed by one-way ANOVA and means were separated by the Duncan's multiple rang test.

Results and Discussion

Serum Total cholesterol (TC), Non HDL cholesterol (LDL-C) and Triglyceride (TG) concentrations were lower ($P<0.05$) in rats fed with the BBF and MIF diets compared that of the CNF. Significantly higher ($P < 0.05$) lactobacilli population was found in rats fed with DAF and MIF diets compared to CNF.

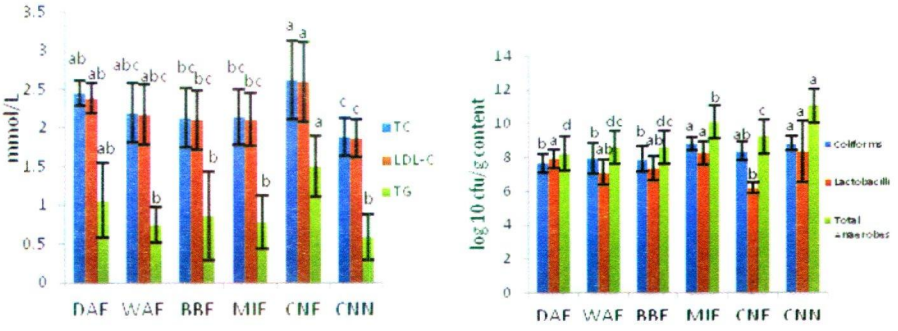


Figure 1: Serum lipids in rats fed experimental diets for 6 weeks
Figure 2: Caecal bacterial population in rats fed experimental diets for 6 weeks

Conclusion

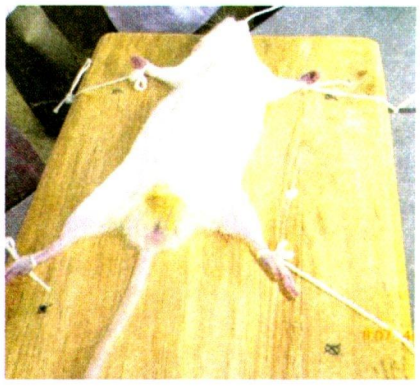
Cowpea incorporated experimental diets modulated the serum lipid metabolism and cecal fermentation in Wistar rats.

References

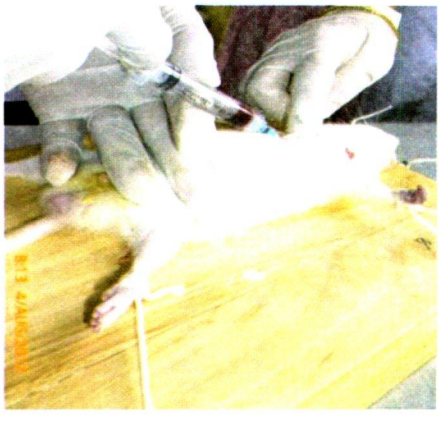
1. Frota, K. M. G., Mendonca, S., Saldiva, P. H. N., Cruz, R. J. and Ar^Eas, J. A. G. (2008). Cholesterol-Lowering Properties of Whole Cowpea Seed and its Protein Isolate in Hamsters. *Journal of Food Science*, **73** (9): 235-240.

2. Reeves, P. G., Nielsen, F. H. and Fahey, G. C. J. (1993). AIN-93 purified diets for laboratory rodents: final report of the American Institute of Nutrition ad hoc writing committee on the reformulation of the AIN-76A rodent diet. *Journal of Nutrition*, **123** (11): 1939-1954.

Rat study

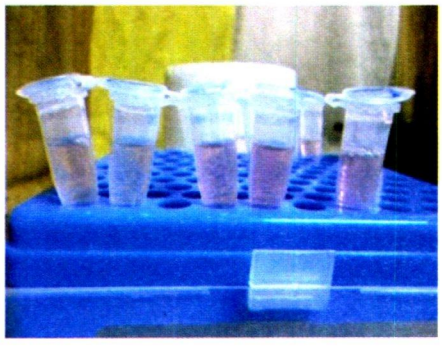


Preparation for dissection



Obtaining blood samples

Separation of organs



Blood samples analysis

Culturing for microbial study

7.4.2 Micro nutrient content of *Moringa oleifera* (Murunga) leaves from different agro-climatic locations in Sri Lanka

O.S Perera, R.Liyanage, S.A.Kulasooriya

Food Science and Nutrition Project, Institute of Fundamental Studies, Hantana Road, Kandy

Abstract

Micronutrient malnutrition especially iron, zinc and calcium deficiency among children and pregnant mothers has become a major health issue in Sri Lanka. *Moringa oleifera* is an important multipurpose tropical tree under-recognized for its nutritional properties. Latest research findings have shown that *M. oleifera* leaves are a rich source of micronutrients, specially needed during pregnancy and lactation (Fuglie, 2001 and Marcu, 2005). However, no study has been done in Sri Lanka to evaluate the micro nutrient content of *M. oleifera* leaves. The objective of the present study was to analyze the iron, zinc, calcium, potassium and magnesium content in *M. oleifera* leaves collected from eight different districts of Sri Lanka. The collected samples were dried, powdered microwave digested (wet ashing) and were analyzed through Flame Atomic Absorption Spectrophotometer (FAAS) against each element standard. According to the data iron, zinc, calcium, potassium and magnesium (per 100 g dry powder) content were in the range of 6-26 mg, 1-5 mg, 1100-1600 mg, 1600-2400 mg, and 290-818 mg respectively. Leaf samples collected from Polonnaruwa District showed significantly higher ($p \leq 0.05$) values for iron, zinc and potassium content when compared with those from the other districts.

Key words: leaves, malnutrition, micronutrients, *Moringa oleifera,* Sri Lanka

References

1. Marcu, M.G. 2005. *Miracle Tree.* La Canada: KOS Health publications.
2. Fuglie, L.J. (ed.) 2001. The Miracle Tree: The Multiple Attributes of *Moringa.* Dakar: Senegal

7.4.3 Nutritional Properties of *Spirulina patensis*

C. Jayathilake, O. Perera, R. Liyanage, S.A. Kulasooriya

Food Science nd Nutrition Project, Institute of Fundamental Studies, Hantana Road, Kandy

The complex lifestyles and characteristic food habits compel more people to have food supplementation. *Spirulina platensis* is famous worldwide among people for its nutritional, therapeutic and financial aspects. In this backdrop, the present study was carried out with *S. platensis* grown under green house conditions, at the Institute of Fundamental Studies with the objectives of determining its proximate composition, quantifying the K, Ca, Fe and Zn as important minerals, its antioxidant activity and the total phenol content. The proximate composition was estimated done by the procedure of A.O.A.C., 2010. Micro-nutrients: K, Ca, Fe and Zn were quantified using the microwave digestion followed by Atomic Absorption Spectrophotometric measurements. Antioxidant activity was determined using 2,2-diphenyl-1-1-picrylhydrazyl radical (DPPH) assay and using butylated hydroxyl toluene (BHT) as the standard. Total phenol content was quantified using the Gallic acid as the standard and foiln-ciocalteu (FC) reagent. UV- visible spectrophotometer was used for the analysis of antioxidant activity and total phenol content. *S. platensis* contained 11.43 ± 0.15% moisture, 13.00 ± 0.50% ash, 12.58 ± 0.80% crude fat, 0.78 ± 0.02% crude fiber and 60.01 ± 0.24% crude protein. Calculated Nitrogen free extract is 2.13%. It contained mg/ 100g, 13.52 ± 0.77 K, 1.68 ± 0.12 Ca, 1.44 ± 0.22 Fe and 0.023 ± 0.02 Zn on dry weight basis. *S. platensis* exhibited higher inhibitory activity

against DPPH with IC 50 value of 375 mg/ml, and its total phenol content was 1.02mg/g dry weight. *S. platensis* contained proteins about 3 times higher than legumes: Cowpea and Mung Bean; beef, goat, chicken, and about 5 times than hen eggs; 3-4 times than crab, mackerel, pollock, prawn and canned salmon quantitatively. Its high amount of protein, higher content of Iron, Potassium, Calcium and being a good source of Zinc and Antioxidants are added advantages. This study also shows that the *S. platensis* is a concentrated source in nutritional and therapeutic aspects than most of the foods consumed currently by the average Sri Lankan. It is best used as a food supplement than a food by itself.

Key words- *Spirulina platensis*, Nutrition, Protein, Minerals, Antioxidant, Total phenol

Human Resource Development

Students registered for M.Phil degree

Ms. O.S.Perera is registered for M.Phil degree at PGIA, University of Peradeniya.
Title of thesis: Effect of commonly consumed cowpea cultivars incorporated experimental diets on serum lipids, liver antioxidative capacity and caecal fermentation in rats

Research assistant- Mr. Nishantha Wijesuriya was recruited under a NSF grant

Students trained during 2012

Volunteer research assistants

1. Ms.Ruksheela Jayamini Bangamuwage (6 months)
2. Mr.Susantha Herath Ekanayake-Pre intern (3 months)
3. Subashi Ubayawardhana- Undergraduate student, Univeristy of Peradeniya (two weeks)
4. Sumudu Sithara Amarasekara- Undergraduate student, Univeristy of Peradeniya (two weeks)

Supervision of final year undergradaute students

1. Ms.RMBKS Rathnamala- Final year student, Faculty of Agriculture, University of Peradeniya (6 months).
2. Ms.RMGCK Jayathilake- Final year student, Faculty of Agriculture, University of Peradeniya (6 months).
3. Ms.DWMMM Kumari-Final year student, Faculty of Agriculture,University of Peradeniya (6 months).
4. Mr.Itan Lakshan-Final year student, Faculty of Agriculture,University of Peradeniya (6 months).
5. Ms.Chathurika Rathnayaka- Final year student, Faculty of Agriculture, University of Peradeniya (6 months).
6. Mr.D.M.A.B. Dissanayake-Final Year Student, Uvawellassa University (3 months).
7. Ms.G.W.A.S. Lakmini-Faculty of Agriculture, Rajarata University of Sri Lanka (6 months).
8. Ms.D.S.K. Medagoda-Final Year student, Uvawellassa University (one week).
9. Ms.Nishani Weerasinghe- Final Year student, Uvawellassa University (one week).

7.5 MOLECULAR BIOLOGY AND GENETICS

7.5.1 CELL BIOLOGY

Project Leader: Dr. D.N. Magana-Arachchi (*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 & tuberculosis with sub projects in each category in order to explore resources, improve human welfare and to contribute to national development.

Isolation & identification of microorganisms and their effects on humans

Cyanobacteria and archaea are fascinating organisms that possess features familiar to both prokaryotic and eukaryotic branches of the tree of life. 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 species in hot springs and water reservoirs in Sri Lanka. The cyanobacterial toxins of concern as potential human health hazards are those known to occur widely in drinking water sources. Determination of the toxigenicity of the cyanobacteria gives a warning of potential toxicity development and permits early intervention to avoid health problems. The monitoring of toxicity levels in water bodies similar as in other countries, is necessary to minimize potential health risks.

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 world wide. Concern about cyanobacterial blooms in fresh waters in Sri Lanka has also grown in recent years due to an epidemic of Chronic Kidney Disease of unknown aetiology (CKDu) prevailing in 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 the 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.

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, diabetics etc.) using Real time 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. One of the most important challenges in the control of TB is a rapid diagnosis of cases and the optimization of anti tuberculous treatment, mainly to prevent the development of resistance and the dissemination of resistant strains. The project was completed in October and the final report was submitted to NRC. 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. Therefore this technique could be used to direct diagnosis of drug susceptibility which will reduce the time taken for traditional culture assays.

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

Atypical mycobacterium is one of the common infections causing organism, 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 is in the final stages of completion.

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 is focussed on characterization of *M. tuberculosis* isolates, obtained from patients attending the Central Chest Clinic Kandy and from Bogambara prison by 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.

Research Assistants: Ms. R.P. Wanigatunge (IFS), Ms. H.M. Liyanage (IFS)
Ms. D.K. Weerasekara (IFS), Ms. S. Maheswaran (NRC –till 31st October)

Research Expertise and Technical Assistance for *Spirulina* Project:
Prof. S.A. Kulasooriya (Visiting Research Professor), Mr. A. Tennakone

Collaborations: Dr. N.V. Chandrasekaran (University of Colombo), Dr. T. Abeysekara (General Hospital, Kandy), Prof. V. Thevanesam (University of Peradeniya) Dr. D. Medagedara (General Hospital, Kandy), Prof. S. Yasawardena (University of Sri Jayewardenepura)

Cell Biology Research Group-2012

7.5.1.1 Molecular Phylogenetics and Microcystin Production of Cyanobacteria

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

Cell Biology, Institute of Fundamental Studies, Kandy

Introduction

Cyanobacteria are a huge group of photosynthetic bacteria found in almost every environment on Earth, including hot springs, deserts and the Antarctic. Several cyanobacterial strains produce toxins that can affect the aquatic biota and also cause health problems in human and animal populations. Globally, the most frequent cyanobacterial toxins found in freshwater blooms are hepatotoxic microcystins.

Aims and Objectives

The objectives of this study were to characterize cyanobacterial isolates from different water reservoirs using morphological and molecular analyses, and to evaluate the production of the microcystins by cyanobacterial isolates.

Results

To characterize diversity of cyanobacteria in reservoirs, water and soil samples were collected from Thibbatu wewa, Siyambala wewa, Bibila Danwehera tank, Karawilahena wewa, Nalanda dam and Ihala Nochchikulama wewa. Cyanobacteria were tentatively identified as *Limnothrix* sp., *Leptolyngbya* sp., *Phormidium* sp., *Synechocystis* sp., *Pseudoanabaena* sp., *Chroococcus* sp. and *Aphanothece* sp. All DNA samples submitted to PCR reactions from the environmental water samples and the cultured isolates for the 16S rRNA gene, yielded the unique fragment of about 450 bp, using the cyanobacterial specific oligonucleotide primers. The combination of 16S rRNA gene amplification, DGGE, and sequence analysis of samples collected from Rangiriulpotha, Kanniya, Nelumwewa, Mahaoya and Wahawa hot springs confirmed the presence of cyanobacterial species belonging to the genus *Chroococcidiopsis*, *Oscillatoria*, *Calothrix*, *Leptolyngbya* and *Xenococcus*.
PCR results confirmed the potential microcystin producing ability of *Chroococcidiopsis*, *Nostoc* and *Anabaena* strains using *mcyA* gene. From HPLC analysis microcystin -RR was detected in *Chroococcidiopsis* strains 1R and L5, microcystin -LR was detected in *Chroococcidiopsis* strains 1R and D3, while microcystin -YR, was detected in 1R, L5, Batti.6.2, D3 and YRS 4a. The total microcystin concentrations of *M. aeruginosa* (PCC 7941), *M. aeruginosa* BL and *Chroococcidiopsis* isolates were determined using PPI assay.

7.5.1.2 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

Isolation and molecular characterization of *Cylindrospermopsis* strains and determination of whether cyanotoxins is a risk factor for the Chronic Kidney Disease of unknown aetiology (CKDu).

Results

Water samples from Anuradhapura, Girandurukotte and Nikawewa/Polpithigama areas were collected. Blood samples from CKDu patients attending to Girandurukotte renal clinic were also collected. Morphological observations were made from control water samples collected from Jaffna, Monaragala and Kandy area. Under the microscope, *Aphanothece, Dermocarpa, Calothrix, Phormidium, Chroococcidiopsis, Synechocystis, Synechococcus, Anabaena, Chroococcus, Westiellopsis, Xenococcus, Oscillatoria, Chlorogloeopsis, Limnothrix,* etc. species were tentatively identified as toxin producers. Genomic DNA was extracted from pure cultures isolated from reservoirs and CKDu patients water samples and PCR was done with 16S rRNA to identify cyanobacteria. 22 samples were sequenced and were identified as *Hapalosiphon, Leptolyngbya, Tolypothrix, Phormidium, Mastigocladus, Anabaena, Nostoc, Chroococcus* and uncultured cyanobacteria. Another eight environmental water samples were amplified for 16S rRNA and cyt gene. Samples were sequenced and were identified as *Phormidium, Oscillatoria, Raphidiopsis, Cylindrospermopsis* and uncultured cyanobacteria. Genomic DNA was isolated from CKDu patients' blood samples and PCR was done for 50 samples using 16S rRNA to identify the presence of cyanobacteria in their blood. Null amplification was resulted confirming the absence of cyanobacteria. Microcystest was performed for eight pure cultures and 25 Nikawewa/ Polpithigama environmental samples and quantified microcystin concentrations (mean conc. 0.952 ug/L). ELISA test was performed for same Nikawewa/Polpithigama samples and quantified cylindrospermopsin concentrations (mean conc. 0.036 ng/ml). Cyanotoxins were extracted from two reservoirs water samples and two CKDu patients' blood samples for HPLC analysis.

7.5.1.3 Rapid Detection of Drug-Resistant *Mycobacterium tuberculosis* Strains using PCR assays

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

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

Introduction

The emergence of drug resistant strains of *Mycobacterium tuberculosis* is an increasing problem in developed and developing countries. Drug resistant tuberculosis (DR-TB) can be life-threatening and is a threat to tuberculosis control programmes. Early detection is essential for the efficient treatment and control of DR-TB.

Objective

To determine the pattern of drug resistance of *M. tuberculosis* from tuberculosis patients attending Central Chest Clinic, Kandy, Sri Lanka based on the culture & PCR methodology targeting the mutations in *rpoB*, *inhA* and *katG* genes.

Results

A total of 275 sputum specimens were obtained from tuberculosis patients who were positive for acid fast bacilli and also as a control population of 25 from patients attending the same clinic, who were negative for acid fast bacilli. Treated specimens were cultured. Drug sensitivity tests (DST) for isoniazid (INH) and rifampin (RIF) were carried out on L-J / MB 7H10 medium, using the proportion method. Of these 161(64.4%) isolates were confirmed as MTB complex and the rest were identified as MOTT by both biochemical and molecular analysis. In this study, 32 (12.8%) *M. tuberculosis* complex isolates were found to be RIF resistant while being sensitive to INH. Six (2.4%) of the isolates were MDR. Mutations were observed in both inside and outside of the rifampin resistance-determining region (RRDR) of the *rpo*B gene. Using $H_{37}RV$ of the *M. tuberculosis* as the standard, phenotypically identified DR-TB strains were successfully detected with developed Multiplex PCR (*inhA* + *rpo*B, *katG* + *rpo*B). Being a rapid method the technique can be used for diagnostic purposes.

This work was supported by a grant (No.07-47) from National Research Council of Sri Lanka.

7.5.1.4 Detection of Non-tuberculosis Mycobacteria (NTM) in Bronchoscopy Samples using Molecular Typing

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

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

Introduction

Non-tuberculous mycobacteria (NTM), mycobacteria other than tuberculosis (MOTT) or atypical mycobacteria include those species not belonging to the *Mycobacterium tuberculosis* complex.

Objective

To develop a simple assay based on Polymerase Chain Reaction (PCR) methodology for definitive diagnosis of mycobacterial infection.

Results

Bronchoscopy specimens (n=202) were collected from patients attending the Teaching Hospital Kandy. Four isolates of 46 AFB positive cultures had rapidly growing mycobacteria (~280-320 bp DNA fragment), 21 isolates had slowly growing mycobacteria (~200-220 bp DNA fragment) and 15 isolates had both bands indicating both rapid and slow growing mycobacteria. DNA sequence analysis revealed the presence of *Nocardia, M. intracellulare* and *M. phocaicum.* Six isolates of *Mycobacterium sp.* and seven *M. tuberculosis* strains were also identified by sequencing. *Hae*III digestion of $H_{37}Rv$ yielded 120 bp and 50 bp bands, *M. bovis* produced 120 bp, 100 bp and 50 bp DNA fragments, *M. phocaicum* had 150 bp fragment and *Nocardia* had 180 bp and 200 bp fragments. *Cfo*I digestion of *M. bovis* yielded 130 bp and 100 bp DNA fragments and *M. phocaicum* had 230 bp and 100 bp fragments.

This work was partially supported by a grant from Anti –TB campaign of Sri Lanka.

7.5.1.5 An Optimized MIRU-VNTR Typing System and Spoligotyping for Population-Based Molecular Epidemiology Studies of Tuberculosis

D.K. Weerasekera[1], D.N. Magana-Arachchi[1], V. Thevanesam[2], D. Madegedara[3]

Cell Biology Project, Institute of Fundamental Studies, Hantana Road, Kandy[1], Faculty of Medicine, University of Peradeniya[2], Respiratory unit, Central Chest Clinic, Kandy[3]

Introduction

During recent years, tuberculosis epidemiology has successfully been analyzed by applying both classical epidemiological and molecular strain typing techniques in population based studies[1]. Therefore, it is to be expected that by rapidly finding strains with identical fingerprints, the putative sources of infection can be tracked more reliably and easily than by the present day practice of contact tracing using skin testing with tuberculin.

Objective

To characterize the MTB isolates by spoligotyping and MIRU-VNTR genotyping techniques.

Results

A total of 100 sputum specimens from the Chest Clinic, Kandy and 19 sputum specimens from Bogambara prison were processed using 4% NaOH and cultured on LJ and MB7H10 media. The cultures were observed for 8 weeks at 37 °C until the appearance of colonies. Cultures arising from prison samples consisted mycobacteria and it was determined by AFB staining. Genomic DNA was extracted from cultured mycobacteria using standard CTAB/NaCl method. DNA extractions were done for sputum samples using the standard Booms method.

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Human Resource Development

Students registered for Ph.D., M. Phil, and M.Sc. degrees

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 M.Phil at University of Colombo
   Title: 'Identification and molecular characterization of *Cylindrospermopsis* species in Sri Lankan water bodies'
3. D.K. Weerasekera (IFS), Registered for a M.Phil at 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. Ms. D.M.D.P.K. Bandara (Volunteer), Registered for a M.Sc at University of Peradeniya
   Title; 'Detection of WISE gene in *Mycobacterium tuberculosis*'

Thesis accepted with minor corrections.

Students trained during 2012

Volunteer Research Assistants

1. Nilmini Perera : Five months (Full time)
2. Sachini Meegahakumbura : Two months (Full time)
3. Nadeeka Udawatta : Four months (Full time)

Undergraduate students

4. Yushra Thanzeel : Two months (Full time/Part time)
5. Chameli Samarawickrama ; Three months (Full time/Part time)

7.5.2. MICROBIAL BIOTECHNOLOGY

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

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

Description of Project

World food production is in jeopardy from conventional farming methods that have degraded soils, polluted water and caused the loss of animal and plant biodiversity. Biodiversity loss frequently increases disease transmission and buildup of allelopathic compounds, resulting in gradual decline in crop productivity and ultimate dieback of plants. It is reported that 40% of global agricultural lands is already degraded, as reflected from greatly reduced yields and a further 9% is degraded to the level that they cannot be reclaimed for productive use by farm level measures (Bossio et al., 2010). Sustainable land management methods such as land sharing/sparing, organic agriculture, crop rotation, and so on have been proposed as a unifying theme for current global efforts on combating the loss of biodiversity, desertification and climate change. However, there are limits to those management methods due to ever increasing global food demand, particularly in the tropics. Therefore, we have to look for methods that sustain productivity of large-scale conventional croplands even with continuous mono-cropping.

It is apparent that we have not fully understood or considered the importance of microbes in sustainability of conventional agriculture. In sustaining the productivity of croplands, we have been manipulating frequently plant and animal components in the agro-ecosystems, as mentioned above, which are more laborious, time-consuming and less efficient. Direct application of developed microbial communities in biofilm mode called biofilmed biofertilisers (BFBFs) has been shown recently to start restoring depleted tropical cropland soils, soon after their application, within 1–2 months, with better yields (Seneviratne et al., 2011). Interestingly, the BFBFs have shown that they can produce equal or even relatively high yields with only 50% of recommended chemical fertilizers of several crops, in comparison to 100% of the fertilizers, from the first year of their application. A major role of the BFBFs in the soil is the increase of microbial diversity, thus improving ecosystem functioning and sustainability. Interactions among microbes in the BFBFs have been observed to release diverse compounds (e.g. low molecular weight sugars, amino acids, etc.), which induce to break dormancy of cysts, spores, akinetes, conidia, etc. in the soil microbial propagule bank (Seneviratne and Kulasooriya, 2013). When such compounds become increasingly available, it also allows resuscitating microbial cells to grow with a broader substrate spectrum. Thus, it is clear that the application of the BFBFs tends to break dormancy of microbial propagules, which causes emergence of a diverse microflora. On the contrary, it is well known that chemical fertilizer application collapses microbial communities, leading to emergence of a community with a low diversity. In some cases, cell-to-cell communication via quorum sensing is reported to allow resuscitating cells to break dormancy of other dormant cells. In biofilm formation, quorum sensing is a prerequisite, which helps establish the biofilm. Therefore, the role of BFBFs in breaking dormancy of the microbial propagule bank in this manner is also obvious. These processes contribute to strengthen biodiversity–ecosystem functioning relationship, which lead to ecosystem sustainability.

Thus, the overall objective of the project is to introduce microbes into the soil in the form of BFBFs for compensating their collapse in conventional agriculture. Use of BFBFs in agriculture saves foreign exchange spent on fertilizer imports and helps to conserve the environment. The progress of this project involving different applications of the BFBFs are summarized below.

Developing BFBFs for potato

The objective of this study is to develop a BFBFs formulation to potato. Initially, potato planted to a virgin soil in pots was uprooted and fungi and bacteria were isolated from the roots, according to protocols developed by the MBU, IFS. Isolated microbes were then inoculated to potato in a sand pot experiment to investigate their pathogenicity. Bacteria were then grown in CCM for isolation of nitrogen fixers. The isolated ones are now being subjected to evaluate nitrogenase activity (ARA) using GC.

Testing new formulations of BFBFs (cyanobacterial and fungal-bacterial BFBFs) for rice

The objective of this study was to further improve existing cyanobacterial and fungal-bacterial BFBFs used for rice. Monocultures of bacteria, fungi and cyanobacteria of the existing BFBFs and newly added cultures to the culture collection were screened for rice plant growth in a soil pot experiment. Then, the selected microbes were formulated to bipartite and tripartite biofilms. They were tested for nitrogenase activity and plant growth. Tripartite biofilm of cyanobacterial BFBFs showed very high nitrogenase activity (ca. 10-fold higher) compared to bipartite biofilms and monocultures.

Yield of maize with BFBFs application in six farmer field experiments at Mahiyangana and Kandekatiya

The BFBFs were tested for maize in six locations to investigate crop response in larger plots of 9 m^2, in order to validate the effect of BFBFs 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 30-40% seed yield increases compared to 100% CF providing both CF reduction and yield increase benefits.

Testing BFBFs for vegetables in home gardens

Studies were conducted in 6 locations; Mahiyanganaya, Bibile, Hatton, Minipe, Polonnaruwa and Horana with 12 vegetables; brinjal, radish, maize, mung bean, capsicum, cabbage, tomato, bitter gourd, pole bean, okra and chili. There were 4 treatments in each location; 100% CF, 50% CF + BFBFs, BFBFs alone and no amendment control, in 3 plots of 8' x 3' for each treatment. Yield increases over control with BFBFs alone, 100% CF and 50% CF + BFBFs, were recorded up to 473%, 847% and 1230%, respectively.

Visiting Research Professor:	Prof. S.A. Kulasooriya
Research Assistants:	H.M.L.I. Herath, K.N.S. Weeraratne, U.V.A. Buddhika, S. Ekanayake
Senior Staff Technical Officers:	R.C.K. Karunaratne, A. K. Pathirana
Lab Attendant:	M. A. Lal
Collaborators:	Prof. Ivan Kennedy, University of Sydney, Australia.

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7.5.2.2 Developing a Method to Culture Yet Unculturable Soil Bacteria and Fungi Using Exudates of Developed Fungal-bacterial Biofilms

G Seneviratne[1], H. M. L.I. Herath[1], A.S.F. Rifana[2]

[1]*Microbial Biotechnology Unit, Institute of Fundamental Studies, Hantana Road, Kandy*
[2]*Faculty of Agriculture, Rajarata University of Sri Lanka, Puliyankulama, Anuradhapura*

Less than 1% of bacteria from natural habitats or environments could be cultured with the help of conventional or traditional culturing techniques which consist of standard culture media and culture conditions (Amann *et al.*, 1995). Thus, cultivable proportion of soil bacteria is not representative of the total phylogenetic diversity, since members of 11 out of 39 bacterial divisions have not been cultured yet (Leadbetter, 2003). A similar situation applies for fungi too. Present study was carried out to evaluate whether exudates of fungal-bacterial biofilms (FBBs, Seneviratne *et al.*, 2008) can satisfy the multiple growth requirements of non cultivable bacteria and fungi. Experiment was focused to compare population characteristics of different bacteria and fungi on existing culture methods [i.e. nutrient agar (NA), potato dextrose agar (PDA) and disk diffusion method (DD)], in comparison to NA or PDA with 50% FBB exudates added media (BFM). Fourier transform infrared (FTIR) spectroscopy was used to characterize and classify microbes. *Aspergillus* species was isolated from all three media. *Acremonium* and *Penicillium* species with different morphological characters were isolated from DD and BFM media. Species richness was high in BFM compared to PDA and DD media. *Bacillus*, *Clostridium*, *Corynebacterium*, *Micrococcus* and *Staphylococcus* species were found in all three culturing methods. Additionally, Enterobacteriaceae was isolated from DD and BFM media. Importantly high numbers of bacterial strains from each species were isolated from BFM media. This ensured that biofilm exudates added media enhanced the growth of different bacterial consortia. Therefore, BFM media can be used for culturing of yet unculturable bacteria and fungi compared to existing methods.

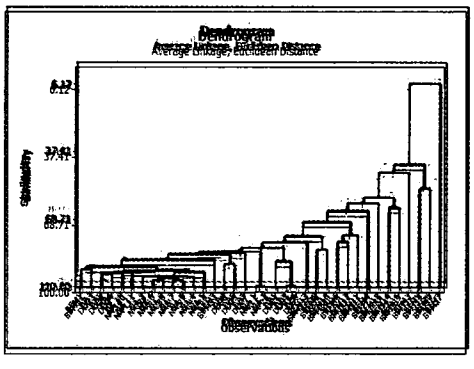

Figure 1. Classification scheme of FTIR spectra of bacterial strains from nutrient agar (NA), disk diffusion medium (DD), and fungal-bacterial biofilm exudates added medium (BFM).

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Human Resource Development

Reading for Ph. D	D. A. Hemagamage and D. Sinhalage (Uva Wellassa University)
M. Phil. Research projects	R.D.A. Gunasekara and D.D.N. Sripal, (on-going)- (University of Peradeniya)

B. Sc. Research projects (completed)

J.P.H. Upulika, A.P.L.N.S. Jayakody and A.S.F. Rifana (Rajarata University)

Volunteers trained during 2012

1. C. Seneviratne and A. N. Abeykoon (National Botanic Garden)
2. D.S. Wijenayake (January - August 2012)
3. S. Shabnam (February – April 2012)
4. S. Gunaratne (February 2012- to date)
5. S. Mayadunne (August 2012- to date)
6. M. Seneviratne (October 2012-to date)
7. I.R. Imtiaz (December 2012-)
8. S.U. Welmillage (December 2012-)

7.5.3 PLANT BIOLOGY

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

Description of the project

Biomass in dry forests

According to the Forest Department assessment, the natural forest cover in Sri Lanka is nearly 29% of which 53% is in the dry zone. The dry zone forests did not receive the attention of scientists in the recent past due to their location in the conflict areas and hence little information is available of these forests in contrast to the wet zone forests. We have completed a study based on a past forest inventory of our dry zone forests, and estimated the biomass at 50 – 118 Mg/ha, in the late 1950's when the forest cover was over 50% of the land area. Using this data we also developed a model to estimate the contribution of small diameter trees to the total biomass, which are omitted during the inventory since they do not contribute to the commercial harvest. It was also found that five species contribute to 37% of the total biomass of the forests.

Environmental remediation

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 to the environment is the major cause of heavy metal pollution. 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 techniques for heavy metal removal.

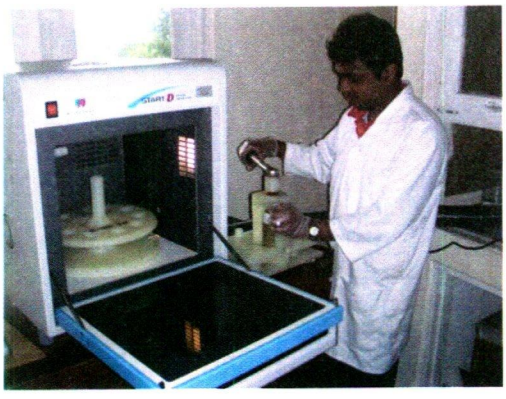
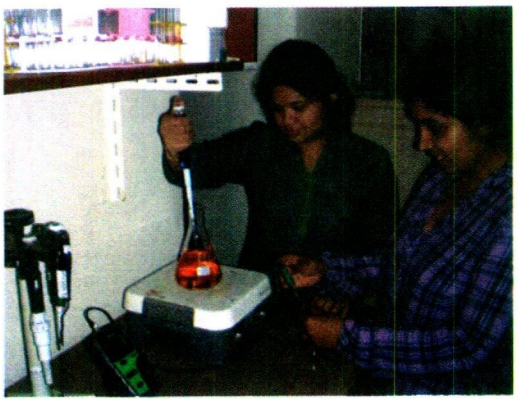
Certain plants are capable of uptake and accumulation of high levels of toxic heavy metals. These plants can be used to remove heavy metals from the contaminated environments and this technique is called phytoremediation. On the other hand, biosorption utilizes the ability of non-living biological materials to adsorb heavy metals on to their surfaces and thereby removing the metals from the system. In our project, we are carrying out studies on different plants and non-living biological materials to determine their potential for phytoremediation or biosorption of selected heavy metals such as chromium, lead, cadmium and nickel.

Dengue risk map

Dengue is an infectious tropical disease caused by the dengue virus and is transmitted to human by mosquitoes within the genus *Aedes*. The virus has four different types and infection with one type usually gives lifelong immunity to that type, but only short-term immunity to the others. Subsequent infections with different types of virus increase the risk with severe complications. According to the Ministry of Health, Sri Lanka, dengue outbreak has developed into a severe epidemic in the island. As there is no commercially available vaccine, prevention is sought by reducing the habitat and the number of mosquitoes and limiting exposure to bites. Therefore, taking an adequate measure to keep the surroundings clean has been identified as an important method to eliminate the disease.

In this project, our objective is to identify climate and socio-economic factors in the Gampola regions that are contributing to dengue incidence, using statistics and to map them using Geographical Information System (GIS) to prepare Dengue Risk Maps (DRM). The data collection was done for Gampola area and the generated database was analyzed in order to prepare the DRMs. The capability of DRM to identify the risk through environmental and socio-economic factors is essential in elimination of this vector borne disease from the study areas.

Research Assistants:	Mr. P.K.D. Chathuranga, Ms. M. Madannayake, Mr. G.D.A. Nalaka (until April 2012)
Senior Staff Technical Officer:	Ms. S. Jayasundera
Laboratory Attendant:	Mr. R.B. Hapukotuwa
Volunteers:	Mr. D.M.R.E.A. Dissanayake, Mr. P.I. Perera, Ms. W.P.Sugandika Kumari


7.5.3.1 Using Forest Inventory Data to estimate Aboveground Biomass in DryForests

G.D.A. Nalaka and M. C. M. Iqbal

Plant Biology Project, Institute of Fundamental Studies, Hantana Road, Kandy, Sri Lanka

Forest inventory data are a constructive resource for estimating above ground biomass using available allometric equations. In the context of REDD+, developing countries face the challenge of data availability and scientific quantification of the national carbon status in terms of carbon storage and stock changes. In Sri Lanka, dry forests now cover an extent of 78 percent of the total dense forest area. Using forest inventory data which represent 495,200 ha in eight dry zone forests with 3690 plots, we estimated the aboveground biomass using three published allometric models and selected the most appropriate model. Forests were classified into medium yielding, low yielding and non–productive types based on their productivity of commercial timber. The mean aboveground biomass corrected for small diameter trees was 52.9 Mg/ha (non – productive) to 132.9 Mg/ha (medium yield). Five species, with wood densities equal to or greater than 0.9, contributed to 37 percent of the aboveground biomass. The diameter class of 20 – 40 cm made the

highest contribution to the aboveground biomass. These species should be the target of forest management to ensure effective carbon sequestration and alternative sources for ecosystem services provided by these species should be identified.

7.5.3.2 Removal of heavy metals from contaminated environment by plants

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, Hantana Rd., Kandy, [2]Department of Chemistry, University of Peradeniya, Peradeniya, [3]Department of Chemistry, The Open University of Sri Lanka, Nawala.

Introduction

Our environment is being polluted due to various human activities. Heavy metals are one of the common pollutants found in contaminated sites. Since heavy metals do not degrade and are toxic to biological systems, they will continue to be an environmental hazard for a long time unless they are reduced to accepted levels. 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.

Aims & Objectives

Our objective is to determine the potential of selected living/non-living plants or plant parts to remove selected heavy metals from contaminated environmental systems.

Results

Salvinia molesta and ***Azolla pinnata*** are good candidates for phytoremediation of aqueous lead. Their metal uptake capacity depended on the nutrient level in the growth medium. ***Fimbristylis ovata*** from two different habitats (i.e. Ussangada and Pallekele) showed a similar pattern of nickel uptake from serpentine soil. Non-living ***Hydrilla verticillata*** removed 86% of lead in an aqueous solution and the biosorption capacity depended on the medium pH. Nitric acid and sodium carbonate could be used to desorb lead from *Hydrilla*.

7.5.3.3 Dengue Risk mapping in Gampola area

M. C. M. Iqbal, M.P. Madanayake

Plant Biology Project, Institute of Fundamental Studies, Hantana Road., Kandy

Introduction

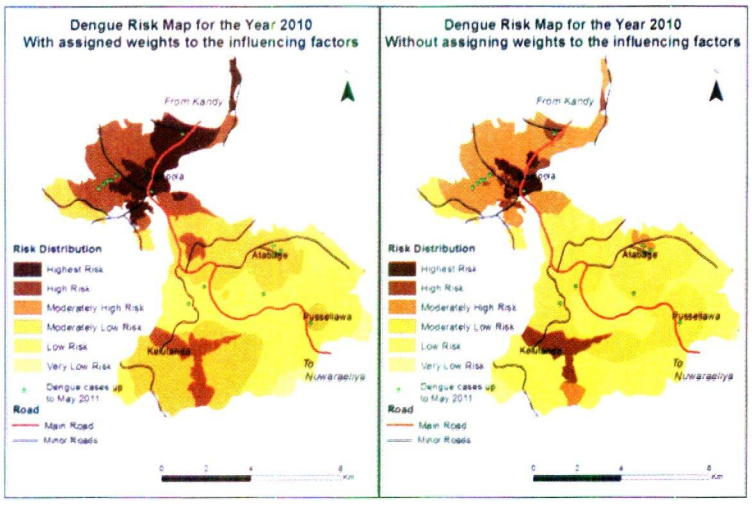
The number of dengue cases is increasing rapidly in Sri Lanka, making it a public health burden. The ongoing global climate change might potentially increase the burden of dengue in future. Therefore, it is necessary to focus on the socio-economical and climate factors that contribute to vector breeding and spread of the virus. GIS is a useful tool to integrate different contributing factors that contribute to disease epidemics. Data collection for this study was done in Gampola area and the patients were geographically located using Global Positioning System (GPS).

Aims & Objectives

Our objective is to obtain a dengue risk map (DRM) for the Gampola area by integrating socio-economic and climate factors, contributing to the spread of dengue.

Results

Two DRMs were prepared by assigning and without assigning weights to the influencing factors as shown below.



Collaborations

Dr. T. Sivananthewerl, Faculty of Agriculture, University of Peradeniya
Prof. N. Priyantha, Department of Chemistry, University of Peradeniya, Peradeniya
Dr. S. S. Iqbal, Department of Chemistry, The Open University of Sri Lanka, Nawala
Dr. J. Gunawardene, Department of Geology, University of Peradeniya, Peradeniya

Human Resource Development

Registered for M.Phil.

1. Mr. P. K. D. Chathuranga (Post Graduate Institute of Sciences, University of Peradeniya)
   Tentative title: Uptake of Heavy Metals by nonliving biomass and removal of metals by selected plant species
2. Ms. Maduni Madanayake (Post Graduate Institute of Sciences, University of Pereadeniya)
   Tentative title: Risk mapping dengue in Gampola area

Registered for M.Sc.

1. Mr. Randika Wijethilake (Post Graduate Institute of Sciences, University of Peradeniya)
2. Mr. Rasika Dissanayake (Post Graduate Institute of Sciences, University of Peradeniya)

Undergraduates and Volunteers

1. Ms. Dilini Ramanayaka – University of Peradeniya, from April/2011 to November/2011 (Full time)
2. Ms. Darshani Wijayawardhana – University of Rajarata, from November/2011 to November/2012 (Part time)
3. Mr. N. Mihiraj – University of Ruhuna, from May 2012 to December 2012
4. Ms. Hasini Delvinne – University of Colombo, from February 2012 to December 2012

Volunteer students

1. Mr. Indika Perera
2. Ms. Sugandi

7.6 NATURAL PRODUCTS

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

Description of the Project

Natural products are organic compounds produced by plants, fungi, other microorganisms, marine organism and lichens. Research activities in the Natural Product Project are focused on the chemistry and bioactivity of secondary metabolites from plants, fungi and edible fruits of Sri Lanka. Identification of polyphenols found in tea, fruits and edible spices is also being carried out. The overall objectives of these projects is the search for bioactive compounds from natural sources as potential resources for control of human and plant diseases.

The bioactivities of extracts and compounds were assessed using bioassays [DPPH (2,2'-diphenyl-1-picrylhydrazyl) 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 α-amylase, β-glucosidase and lipase inhibitors respectively are important in the field of drug research and are now being carried out on various extracts. Specific enzyme inhibitors interact with enzymes and block their activity towards their corresponding natural substrate. These inhibitors are biochemical tools that have potential utility in the treatment of diseases. The α-amylase, β-glucosidase and lipase inhibitors are drug targets for the treatment of diabetes, obesity and hyperlipaemia.

Collaborators

1. Department of Chemistry, Faculty of Science, University of Peredeniya
2. Department of Microbiology, Faculty of Dental Science, University of Peradeniya.
3. Entomology Division, Horticultural and Research Development Institute (HORDI) Gannoruwa

Research Scientist: Dr. K.G.N.P. Piyasena *(from 01.10.2012 - NSF Project)*

Research Assistants:
Ms. A.G.A.W. Alakolanga *(until 17.11.2012)*
Ms. H.M.S.K.H. Bandara
Ms. H.R.W.M.D.P.K Niyangoda *(from 20.06.2012 - NSF project)*
Ms. K.G.E Padmathilake
Ms. A.G.D.D. Silva *(from 16.11.2012)*
Ms. G.G.E.H. De Silva
Ms. A.M.D.A. Siriwardena *(until 03.08.2012)*

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

Natural Products Research Group -2012

7.6.1 Edible Fruits: Chemistry and Bioactivity

H.R.W.M.D.P.K. Niyangoda, R.M.W.C.K. Karunaratne, W.M.A.S. Gangoda, G.G.E.H. De Silva, N.S. Kumar, U.L.B. Jayasinghe

Natural Products Project, IFS, Kandy

Introduction

Fruits have been consumed for centuries by animals and humans and are a reliable source of non-toxic and environmental friendly bioactive compounds. Consumption of fruits has been associated with reduced risk of chronic diseases and some functional declines associated with aging [1]. Bioactivity studies of compounds specific to tropical fruit plants have led to the discovery of new chemical entities with interesting bioactivity and reduced toxicity [2].

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 *Averrhoa bilimbi* (Sinhala: Bilin), *Citrullus lanatus* (Peni Komadu), *Garcinia cambogia* (Goraka), *Limonia acidissima* (Divul), *Manilkara zapota* (Sapodilla), *Nephelium lappaceum* (Rambutan) and *Phyllanthus emblica* (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 ethyl acetate. Residues were sequentially extracted into *n*-hexane, EtOAc and MeOH. MeOH extracts were partitioned with *n*-butanol and water. All extracts were subjected to antifungal activity (TLC bioassay against *Cladosporium 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) assays. Results of the bioassays are listed in Table 1.

Table 1: Results of bioassays of fruit extracts

Fruit		Type of Bioassay					
Scientific name	Local name	Antifungal	Antioxidant	α-amylase inhibition	Brine shrimp lethality	Lipase inhibition	Phytotoxicity
Averrhoa bilimbi	Bilin	++	++	++	++	*nd*	++
Citrullus lanatus	Peni Komadu	*nd*	++	*nd*	++	*nd*	*nd*
Garcinia cambogia	Goraka	-	++	++	++	++	++
Limonia acidissima	Divul	*nd*	++	*nd*	*nd*	*nd*	*nd*
Manilkara zapota	Sapodilla	*nd*	++	++	-	*nd*	
Nephelium lappaceum	Rambutan	*nd*	++	*nd*	++	*nd*	*nd*
Phyllanthus emblica	Nelli	*nd*	++	++	++	*nd*	*nd*

++ at least one extract of the fruit was active; - all the extracts were inactive; *nd* not determined

Four pure compounds were isolated from the EtOAc extract of *G.cambogia* and two were identified as garcinol and 7-epi garcinol. Garcinol showed 50% root inhibition at 250 ppm whereas 7-epi garcinol showed 50% root inhibition at 500 ppm. Garcinol showed potent antioxidant activity IC_{50} at 7.2 ppm (ascorbic acid IC_{50} at 6 ppm) and brine shrimp lethality activity LD_{50} at 5 ppm while 7-epi garcinol showed high antioxidant activity IC_{50} at 4 ppm (ascorbic acid IC_{50} at 6 ppm). Bioassays of other extracts and isolation of compounds from bioactive extracts are in progress.

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7.6.2 Common spices – some studies of bioactivity and enzyme inhibition

W.I.T. Fernando[1,2], H.K.I. Perera[2], S.B.P. Athauda[2], R. Sivakanesan[2], N.S. Kumar[1], U.L.B. Jayasinghe[1]

[1]Natural Products Project, IFS, Kandy,
[2]Department of Biochemistry, Faculty of Medicine, University of Peradeniya

Introduction

Hyperlipidaemia and hyperglycaemia have become serious public health problems, which lead to obesity, vascular diseases and diabetes mellitus. Dietary therapy is important and could be considered as the first choice of prophylactic treatment. Decreasing digestion and absorption of dietary lipids and carbohydrates will be beneficial in controlling hyperlipidaemia and hyperglycaemia.

Methodology and Results

The methanolic crude extracts of ten commonly used spices were subjected to bioassays for antioxidant activity against DPPH radicals using the spectrophotometric method; cytotoxicity against *Artemia salina* using micro-well method; phytotoxicity against *Lactuca sativa* seeds using the germination assay; Lipase inhibitory activity using the colorimetric method and Amylase inhibitory activity using the chromogenic method. Among the crude extracts, *Trigonella foenum-graecum* (25.42 ± 0.32%), *Myristica fragans*(22.7 ± 0.31%) *Cuminum cyminum* (19.17 ± 0.54%), *Elettaria cardamomum* (11.76 ± 0.55 %), *Brassica junce* (8.8 + 0.18 %) and *Coriandrum sativum* (6.19±0.15 %) showed lipase inhibitory activities. *Syzygium Aromaticum* (58.10±0.24 58.3%), *Curcuma longa* (52.2 ± 0.24%), *Cinnamomum zeylanicum* (32.39±0.91%), *Brassica junce* (20.1 + 0.56%),*Foeniculum officinalis* (28.79±0.22%) and *Trigonella foenum-graecum* (8.69±0.35 %) showed amylase inhibitory activities. The crude methanol extract did not display either cytotoxic activity or phytotoxic activity. All the spices showed antioxidant activity with *Coriandrum sativum* (92.8± 0.31%) having the strongest activity.

Boiled extracts of seven spices were used to evaluate the heat stability of the lipase and amylase inhibitors when a significant reduction of the lipase inhibitory activity of the extracts was observed in all extracts after boiling whereas a major decline in the α -amylase inhibitory activities was not observed.

Methanol extracts of *Trigonella foenum-graecum* (TF) and *Cuminum cyminum* (CC). were partitioned by stepwise solvent-solvent extraction process using hexane, ethyl acetate, and water. Highest lipase inhibitory potencies were observed in the aqueous fraction of TF and ethyl acetate fraction of CC.

7.6.3 Endophytic Fungi: Chemistry and Bioactivity

K.G.E. Padmatilake, H.M.S.K.H. Bandara, A.M.D.A. Siriwardena, U.L.B. Jayasinghe, N.S. Kumar

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, and produce secondary metabolites in small quantities through secondary metabolic pathways that are not directly involved in normal growth, development or reproduction. Their major role has been identified as plant defense. Several novel and pharmacologically active molecules have been reported from endophytic fungi. Recently we studied the endophytic fungi associated with the edible fruits *Pouteria campechiana* (Lavulu), *Musa sp.* (Banana) and *Limonia acidissima* (Divul).

Objective

Studies of environmental friendly bioactive compounds originating from endophytic fungi associated with edible fruits.

Methodology and results

Pouteria campechiana (local name - *Lavulu*) is a golden yellow popular edible fruit of the family Sapotaceae growing in tropical countries. Some carotenoids (Lanerolle *et al.*, 2008) and some antioxidant polyphenolic compounds (Ma *et al.*, 2004) have been reported from fruits of *P.*

campechiana and some bioactive compounds have been reported from the genus *Pouteria* (Silva *et al.*, 2009). Neither chemical nor biological investigations have been reported on the endophytic fungi of *Pouteria campechiana.*

Surface sterilized pieces of fruits and seeds of *P. campechiana* were placed on potato dextrose agar (PDA) plates and incubated for 3 days at room temperature. Two fungi SGR and SW from seeds and two fungi FA and FW from the fruits were isolated. Each fungus was inoculated on potato dextrose broth (PDB) and incubated at room temperature while shaking. After 21 days media were filtered through cotton wool. Filtrates were partitioned with EtOAc/H_2O to give (SGREP, SWEP, FAEP, FWEP). The residues were crushed into small pieces and sequentially extracted into EtOAc and MeOH (30 min x 3) separately using a sonicator to give EtOAc extracts (SGRES, SWES, FAES, FWES) and MeOH extracts (SGRMS, SWMS, FAMS, FWMS).

All twelve extracts were subjected to bioassays for antioxidant activity against DPPH (2,2′-diphenyl-1-picrylhydrazyl) radicals using the spectrophotometric method; phytotoxicity using lettuce seeds germination inhibition bioassay; antifungal activity against *Cladosporium cladosporioides* with TLC bioautography method; brine shrimp lethality against *Artemia salina* using the micro-well bioassay and α-amylase inhibition activity using a spectrophotometric method. None of the extracts showed significant antifungal activity, while only FWEP showed α-amylase inhibition activity. SGREP, FWEP, FWES, FWMS and FAEP were significantly toxic for brine shrimps. All twelve extracts showed high antioxidant activity and high phytotoxic activity.

Eight compounds including flavasperone were isolated from the endophytic fungal extracts of *Musa* sp. (Banana) and displayed cytotoxicity and phytotoxicity (*IFS Annual Review 2011*). Due to the low yields of compounds isolated, the fungus was re-grown on PDA, extracted to EtOAc and the same set of compounds was re-isolated. Of the eight pure compounds isolated three compounds showed significant brine shrimp lethality activity and phytotoxicity.

Endophytes from the seeds of *Limonia acidissima*: As reported earlier flavasperone, rubrofusarin B, aurosperone A and fonsecinone D were isolated from the endophytic fungal extracts originating from the seeds of *L. acidissima* (*IFS Annual Review 2011*). All four compounds displayed brine shrimp lethality at LD_{50} - 32 ppm, 40 ppm, 9 ppm, 51 ppm respectively. The phytotoxic activity of flavosperone and rubrofusarin B was found to be significant. None of the isolates showed antifungal activity against against *C. cladosporioides.*

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7.6.4 Polyphenolic compounds in *Cinnamomum. zeylanicum* bark and fruits of *Flacourtia inermis*

A.G.A.W. Alakolanga, U.L.B. Jayasinghe, N.S. Kumar

Natural Products Project, IFS, Kandy

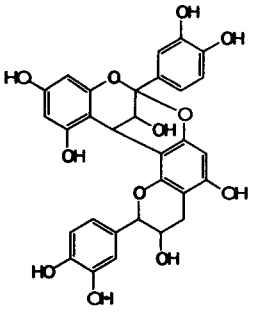
Introduction

Dietary polyphenolic compounds play an important role in the prevention of degenerative diseases such as cancers, cardiovascular diseases and neurodegenerative diseases. We have used Liquid Chromatography/Tandem Mass Spectrometry for the detection of polyphenolic compounds present in *Cinnamomum zeylanicum*, frequently used as a spice, and *Flacourtia inermis* (Lovi), a common edible fruit.

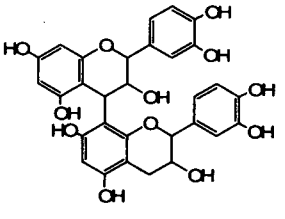
Methods and Result

A total of 37 A-type and B-type PAs and their monomers, catechin and epicatechin at *m/z* 289 $[M-H]^-$ were detected, using Liquid Chromatography/Tandem Mass Spectrometry in a methanol extract of the bark of *C. zeylanicum*. There were A and B-type proanthocyanidin (PA) dimers, trimers, tetramers and pentamers. Five A-type PA dimers, *m/z* 575 $[M-H]^-$; three B-type PA dimers *m/z* 577 $[M-H]^-$; one A-type PA trimer *m/z* 861 $[M-H]^-$; four A-type PA trimers, *m/z* 863 $[M-H]^-$; three B-type PA trimers *m/z* 865 $[M-H]^-$; two A-type PA tetramers *m/z* 1151 $[M-H]^-$; six A-type PA tetramers *m/z* 1151 $[M-H]^-$, ten B-type 1153 $[M-H]^-$; a PA pentamer with one A-type linkage *m/z* 1439 $[M-H]^-$; two B-type PA pentamers, *m/z* 1441$[M-H]^-$ were tentatively identified on the basis of their unique multi step fragmentation pattern in the negative ion mode of tandem mass spectra[1].

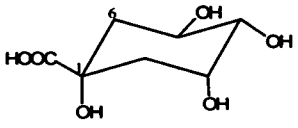
Chlorogenic acids (CGAs) are esters of quinic acid (QA) and the polyphenolic hydroxycinnamic acids of which caffeic acid and ferulic acid are the most common. Esters between shikimic acid and caffeic acid, the caffeoylshikimic acids (CSAs), are less common in nature. MS^2 and MS^3 fragmentation was used to identify the four parent ions due to the hydroxy cinnamic acids detected at m/z 335 (caffeoylshikimic acid, CSA), m/z 354 (Caffeoyl quinic acid, CQA), m/z 367 (Caffeoyl ferulic acid, CFA) and m/z 515 (dicaffeoyl quinic acid DiCQA). These compounds were identified by using the hierarchichal scheme for characterizing chlorogenic acids developed by Clifford et al.[2], to differentiate between the different sub groups of CGAs on the basis of their fragmentation patterns.



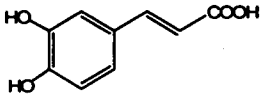
A-type PA dimer



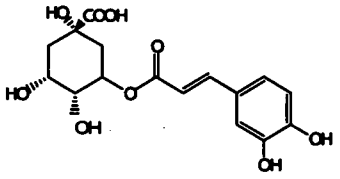
B-type PA dimer



Quinic acid



Caffeic acid



3-CQA

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7.6.5 Edible seeds: Beyond nutritional value

D.S. Jayaweera[1], G.J. Panagoda[2], N.S Kumar[1], B.M.R. Bandara[3], U.L.B. Jayasinghe[1]

[1]Natural Products Project, IFS, Kandy, [2]Division of Microbilogy, Faculty of Dental Science, University of Peradeniya, [3]Department of Chemistry, University of Peradeniya.

Introduction

Edible seeds that are commonly consumed worldwide play a vital role in the human diet. These seeds are rich in lipids, proteins, dietary fiber and amino acids. Scientific studies suggest that whole grains consumed by humans reduce the risk of several diseases including colon cancer, diabetes and coronary heart disease. Most of the studies on edible seeds are limited to their nutritional properties. During the last few years we have carried out studies to explore the possibilities of utilizing edible seeds as a source for environmentally friendly bioactive compounds. Edible seeds have been consumed for thousands years and should have remarkably low toxicological issues associated with their use.

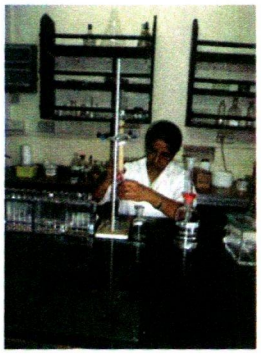
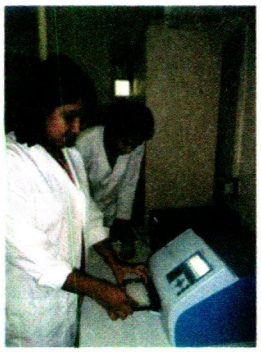
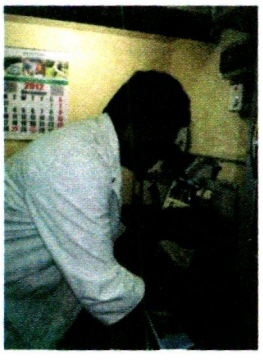
Objective

Identification of environmental friendly bioactive compounds/extracts from edible seeds

Methodology and Results

The methanol extracts of fifteen edible grains used in Sri Lanka were screened. These were *Cicer arietnuam,*(local name: Kadala), *Dolichos biflorus* (Kollu), *Elusine coracana* (Kurakkan), *Lathyrus aphaca* (Batana), *Lens culinaris* (Mysoere dhal), *Mucuna prurens* (Wandurumea), *Vigna radiata* (Mung ata), *Paspalum scrobiculatum* (Amu), *Panicum miliare,* (Meneri), *Vigna mungo* (undu), *Pisum sativum* (Green pea), *Setaria italica* (Tanahal), *Sorgham almum* (Sorgum), *Vigna unguiculata* (Red cowpea), *Zea mayse* (Badairringu) for their antioxidant activity against DPPH, antifungal activity against *Cladosporium cladosporioides*, Brine shrimp lethality against *Artemia salina,* Phytotoxicity against seed germination of *Lactuca sativa*, Mosquito larvicidal activity against *Culex quenqifaciatus,* Anticandidal activity against *Candida albicans, C. glabrata, C. guilliermondii, C. krus, C. parapsilosis, C. rugosa, C. sake* and *C. tropicalis,* enzyme inhibitory activity towards α-amylase, and the hemolysis test and froth test for the presence of saponins. Results are as follows.

Antifungal activity: Only *Pisum sativum* seed extracts showed antifungal activity.
Anticandidal activity: None of the tested seeds extracts showed a positive response.
Antioxidant activity: *Elusine. Coracana, Mucuna prurines, Paspalum scrobiculatum, Setaria italica,Vigna radiata, Sorgham almum, Dolichos biflorus* and *Elusine coracana* showed the presence of antioxidant compounds.
Brine shrimp lethality: *Setaria italica, Vigna radiata, Sorghum almum, Panicum miliare, Eleusine coracana* showed high potential for the presence of toxic compounds, which may be useful in the isolation of cytotoxic compounds.
Mosquito larvicidal activity: The five most potent larvicidal extracts were *Setaria italica, Phaseolus aureus, Sorgham almum, Panicum miliare* and *Elusine coracana*
Phytotoxic activity: *Mucuna pruriens, Sorghum almum, Setaria italica, Paspalum scrobiculatum* and *Vigna radiata* showed the presence of phytotoxic compounds.
Haemolysis and Froth test for saponins: *Mucuna prurines, Paspalum scrobiculatum, Phaseolus aureus, Vigna unguiculata* and *Lathyrus aphaca* extracts are rich in saponins.
α-Amylase inhibition assay: Results were inconclusive

Human Resource Development

a) Post graduate degrees completed

1. K.G.N.P. Piyasena. Ph.D. Title of the thesis: "Allelopathic activity studies of Sri Lankan flora and Chemical investigation of endophytic fungi and terrestrial *Streptomyces* sp." Supervisor: Prof. H.R.W. Dharmaratne

2. W.R.M. Kumbukgolla. M.Phil. "Tea Catechins: Antibacterial activity against Methicillin-Resistant *Staphylococcus aureus* (MRSA) and enhancement of sensitivity of MRSA to oxacillin.
Co-Supervisors. Prof. B.M.R. Bandara, Prof. V. Thevanasam and Prof. N. S. Kumar.

b) Research Assistants registered for Ph.D., M. Phil, and M.Sc. degrees. The tentative title for each student is also indicated.

1. A.G.A.W. Alakolanga, *Separation and structures of flavan-3-ols, their derivatives and biological activity against microbial and other pests"*
2. H.M.S.K.H. Bandara,: "*Chemistry and bioactivity of some fungi associated with edible fruits of Sri Lanka*".
3. W.I.T. Fernando: "*Isolation, purification and characterization of amylase and lipase inhibitors from medicinal plants traditionally used for management of diabetes and cardiovascular diseases*".
4. D.S. Jayaweera: "*Chemistry and Bioactivity of some edible seeds*"
5. R.M.W.C.K. Karunaratne: "*Chemistry and Bio activity of the fruits of Averrhoa bilimbi".*
6. D. Niyangoda: "*Chemistry and Bioactivity of some edible fruits in Sri Lanka*".
7. K.G.E. Padmatilake: "*Chemistry and Bioactivity of some edible fruits of Sri Lanka and fungi associated with them*".
8. G.G.E.H. De Silva: "*Chemistry and bioactivity of spices, fruits and associated fungi*".
9. A.D.M.A. Siriwardena: "*Chemistry and Bioactivity of fungi associated with the fruit of Limonia acidissima and Flacourtia indica".*

c) Undergraduate students trained in Natural Product Laboratories

1. A.S. Gangoda – Pre University Student (*6 months*)
2. H.N. Krishni Fernando – University of Peradeniya (*1 month*)
3. D.M.D. Dissanayake – University of Peradeniya (*1 month*)
4. U.I. Premadasa – University of Peradeniya (*1 month*)

7.7. THEORETICAL AND COMPUTATIONAL SCIENCE

7.7.1 SONOLUMINESCENCE

Project leader: **Prof. Asiri Nanayakkara** (*Research Professor & Team Leader)*

Description of Project

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. 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 [1].

The spectrum of SBSL is fairly broad, extending from above 700 nm to below 190 nm. Intensity of the emitted light increases with decreasing wavelength up to the ultraviolet cutoff limit 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 [2] for applied 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 [3].

There has been large number of theoretical and experimental investigations to explore, understand and predict the above mentioned exotic conditions that take place inside the SBSL bubbles at the time of light emission [4]. Most theoretical / computational models have been based on continuum fluid mechanics (e.g. *Euler* equations or *Navier-Stokes* equations) [4] 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, validity of these models is questionable [5]. Further, all these fluid approaches are limited in their predictive power by the need to represent transport processes and the equation of state.

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

Research Assistants: Prabhath Herath, Sanjeewa Karunawansha, Manoj Wijesingha

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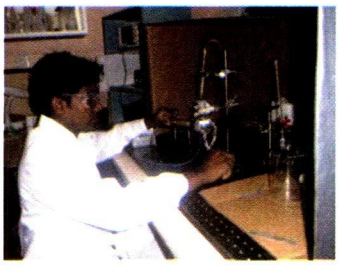
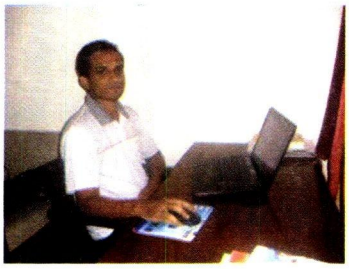




7.7.1.1 Computational investigation of Single Bubble Sonoluminescence

Asiri Nanayakkara, Sanjeewa Karunawansha, Manoj Wijesingha

Single Bubble Sonoluminescence Project, IFS, Kandy

Brief 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 were able to simulate some sonochemical reactions correctly.

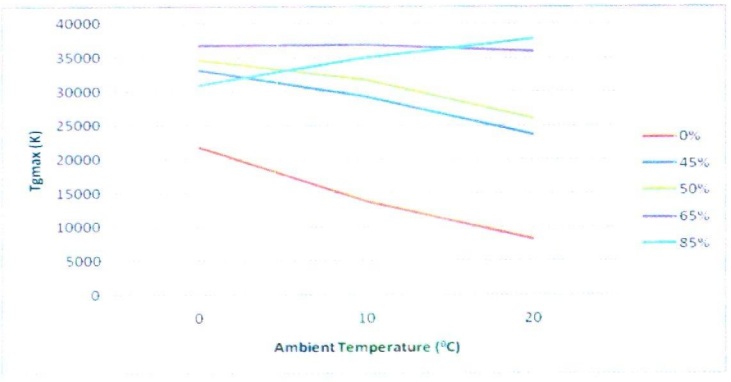
Aims and objectives

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

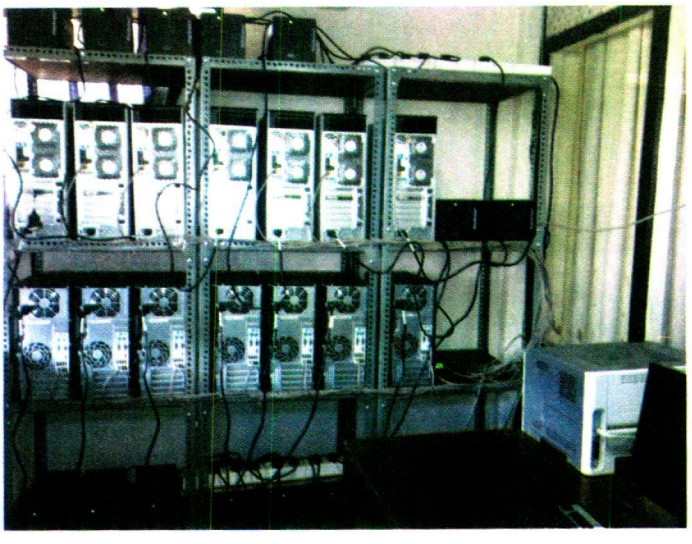
Results

Development of the simulation software based on hydro-dynamical model for simulating collapse stage of the bubble was completed. New important features such as determination of bubble stability (both diffusive stability and positional stability) and calculation of light intensity produced by *Bremsstrahlung* were incorporated into the software. In addition, various user friendly features were also added to the software. Now it is in the production stage. In order to test the accuracy of the software, a few experiments which have been done previously were repeated successfully using the simulation software and correct results and behaviours have been obtained.

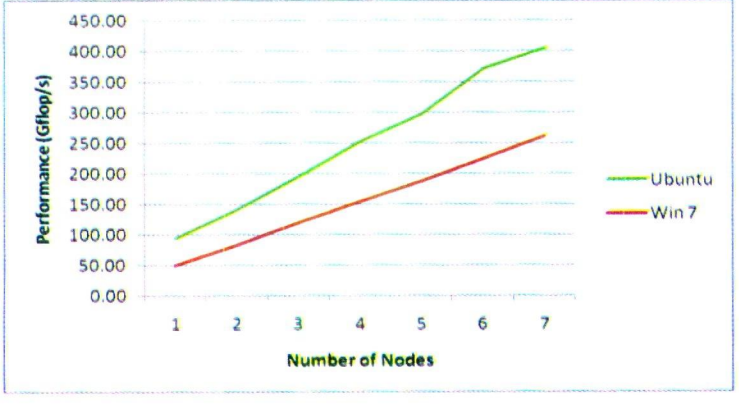
Further we have simulated the ambient temperature dependence of SBSL light intensity in various concentration of sulfuric acid with the software. Unlike in water, the light intensity was found to be increasing with the ambient temperature for high concentration of Sulfuric acid. Results are shown in Figure 1.



Further, the High performance computing (HPC) cluster in our research unit was constructed and configured to run parallel programs. Both MS Windows (Windows 7) and Linux (Ubuntu 12.04) clusters were constructed and configured to run MPI parallel programs.



The performance impact of computational efficiency on HPC clusters with Hyper-Threading Technology was determined. Performance of the cluster was evaluated with standard bench mark packages. A comparison between Windows and Linux operating system was also carried out and results are given below.



Detail investigation 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 sonochemical reactions take place inside the SBSL bubble.

7.7.1.2 Experimental investigation of Single Bubble Sonoluminescence

Asiri Nanayakkara, Prabhath Herath

Single Bubble Sonoluminescence Project, IFS, Kandy

Brief 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 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 those from sulfuric and phosphoric acids.

Results

SBSL was generated for H_2O and H_2SO_4 in our laboratory. We have successfully observed moving Single Bubble Sonoluminescence (m-SBSL) in 85% sulfuric acid. photon count of the SBSL emission was observed using PMT tube, DAQ card and MAT LAB program. Due to very limited consumable budget in 2012, we were unable to purchase most important accessories needed to carry out spectroscopic as well as radial measurements of the bubbles in sulfuric acid. We expect to purchase these accessories in 2013.

However, with accessories available in the laboratory, relative photon counts were observed for SBSL in water and in Fluorescein sodium solutions. This will enable us to determine UV part of the SBSL spectrum which is absorbed by water. The temperature dependence experiment for water and Fluorescein sodium solution was completed.

7.7.2 QUANTUM MECHANICS AND QUANTUM CHAOS

Project Leader: Prof. Asiri Nanayakkara *(Research Professor - Team Leader)*

Brief 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 signature of chaos in quantum mechanics, we have been developing various theoretical and computational methods for multidimensional systems that 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 behaviour of multidimensional systems in the semiclassical limit. (i.e. limit between quantum mechanics and classical mechanics) and classical, semiclassical and quantum mechanical behaviour of both *Hermitian* and *non-Hermitian* Hamiltonian systems.

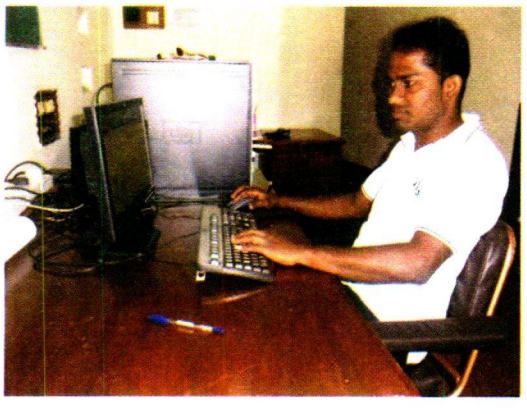
Results

This project has produced 31 research papers 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 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 above method are much simpler than those in WKB methods. In 2012 we have made excellent progress in investigating non-Hermitian systems using asymptotic expansion methods developed by our research unit. We have found previously unknown Hermitian systems, which have the same quantum *eigen* spectra as class of non-Hermitian PT symmetric systems.

(2) In 2012, five research papers on Non-Hermitian systems have been published in Science Citation indexed (SCI) journals. We have submitted three more research manuscripts to SCI journals for publication. Based on research carried out in this project during last several years, we have received an invitation from Prof. Andreas Fring at the Centre for Mathematical Science at City University London, UK to do collaborative work with his research group.

MPhil Student: Thilagarajah Mathanaranjan



Human Resource Development

M.Phil. students: (Research)

1. Prabhath Herath - PGIS, University of Peradeniya.
2. Mr. Thilagarajah Mathanaranjan - PGIS, University of Peradeniya.
3. Mr. Manoj Wijesingha - PGIS, University of Peradeniya

8. CONSULTATIVE AND COLLABORATIVE DIVISION (CCD)

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

Progress of collaborative activities under the CCD has been quite satisfactory during the year under review. While ongoing activities initiated during the previous years continued, a number of new collaborations commenced during 2012. What is included in this section will be confined to the interactions with outside organizations. Results of the studies under the different projects are presented by the respective units conducting them.

Projects continuing from previous years

1. **Collaboration with Nature's Beauty Creations (NBC) PLC on Biofilm-Biofertilizers (BFBFs) for tea**
   IFS scientists: Prof. Gamini Seneviratne and Prof. S. A. Kulasooriya

   Machinery brought from India has been installed in a separate building set aside for the pilot level operations. A couple of trial runs were attempted to scale up the production of inoculants for tea in the low cost medium from lab level to 5L semi-industrial level. A few initial contamination problems have been overcome and field testing of the inoculants produced are being carried out at the NBC premises by Mr. Ananda Jaysekera from the TRI.

   Research results are given 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. Collaborating scientist: Dr. R. M. D. Madegedara, Physician, Respiratory Unit, Teaching Hospital, Kandy.

   Satisfactory progress has been made during 2012 and the project is approaching a successful completion. Research results are presented under the Cell Biology Unit.

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

   IFS scientists: Mr. J. P. Padmasiri, Dr. D. N. Magana-Arachchi and Prof. S. A. Kulasooriya. Collaborators: Dr. S. Yatigammana, Department of Zoology, University of Peradeniya and Dr. S. K. Weragoda, NWSDB. Research Assistant: Ms. Buddhika Perera

   A number of village level electro-coagulation water purification units were installed by Mr. Padmasiri in collaboration with Spectra (Pvt) Limited. Ms. Buddhika Perera has surveyed 61 inland reservoirs covering all the agro-ecological zones of Sri Lanka and recorded their phyto and zooplanktons. She found a number of potential toxin producing cyanobacteria among the phytoplankton with a preponderance of *Cylindrospermopsis* recorded for the 1st time from the Nuwara Eliya District. Dr. Magana-Arachchi measured and quantified algal toxins microcystins and cylindrospermopsins in water samples using ELISA based detection kits.

   Detailed research results are presented under the Water Quality Unit, Cell Biology Unit and the Environmental Biology Unit.

4. **Development of measures to eliminate Chronic Kidney Diseases of unknown etiology (CKDu) in the North Western Province**

IFS scientists: Mr. J. P. Padmasiri, Prof. S. A. Kulasooriya and Dr. D. N. Magana-Arachchi. Collaborators: Dr. R. M. S. K. Ratnayake, Provincial Director of Health Services and other Provincial Medical Officers , Director and scientists of the ITI, Academic Staff members of the Wayamba University. IFS scientists contributed to the preparation of project proposals which covered diverse aspects of the population susceptible for CKDu including their socio-economic status. A certain portion of funds received has been apportioned for research work at the IFS on water quality and algal toxins in water resources used by the targeted population.

5. **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.

Awareness workshops on the quality control and use of biofilm-biofertilizers were held at the IFS for selected field officers from Plenty Foods (PLC) a company with which field trials for maize and certain legumes are being conducted; SARD an NGO with which field trials on vegetables grown in home gardens are being conducted and with the 'GOVI PIYASA' Managers who are the accredited agents of the Agro-Enterprise Division of the Government Department of Agriculture for extension services to farmers for production of a variety of crops including rice. IFS RAs visited several Extension offices of the Department of Agriculture including Vavuniya, Kilinochchi and Jaffna in the company of Mr. Tilekeratne Experimental Officer, Agro-Enterprise Division and has discussions to commence field trials.

Through the mediation of the Secretary to the IFS, discussions were held with the Provincial Minister of Agriculture and his officials of the Wayamba Province. Follow up action was taken to establish field trials on a variety of crops at Anamaduwa, Galgamuwa and Mahawa.

6. **Rhizobial Inoculants Research and Production Facility (RIRPF)**

After moving to the IFS from the PGIS, University of Peradeniya, the RIRPF continued to supply inoculants for about 2500 acres of soybean cultivations by Plenty Foods, the Mahaweli Authority and a few small scale farmers during the Yala season of 2012. Normally during the Maha seasons the demand for inoculants is very low because soybean is grown only for seed production to be used for the next Yala season. This Maha season however, there was an unprecedented demand and inoculants were supplied for nearly 900 acres of soybean. On this basis our target for the 2013 Yala season could be around 30,000 acres. This high demand is due to the policy decision taken by the Government to stop the import of soybean to Sri Lanka. Having earned a gross income of Rs.942,030.00 and spent Rs.574,174.40 for material requirements and payment of emoluments to its employees, the facility has recorded a saving of Rs.367,855.60 during its 1st year of operation.

A landmark event of collaboration with the Rhizobial Inoculant Production Facility took place in December 2012. The IFS was invited to host an *International Master Class on Root Nodule Bacteria for Sustainable Agriculture*. This Class was conducted in collaboration with the Center for Rhizobium Studies (CRS) of the Murdoch University, Western Australia which provided the Resource persons to conduct the teaching programs together with Professors S. A. Kulasooriya and Gamini Seneviratne as the local resource persons. Eleven participants from 8 African and Asian countries including Sri Lanka underwent training from December 1st to 14th 2012. It was a very useful program particularly for microbiologists interested in improving soil fertility and supporting sustainable crop production with the minimum use chemical fertilizers. The participants from Sri Lanka were a scientist from the IFS, a Senior Lecturer from the

The following photographs show some of the extension and field activities on the application of multi microbial inoculants.

Workshop with Plenty Foods field staff

Group photo of Govi Piyasa Managers

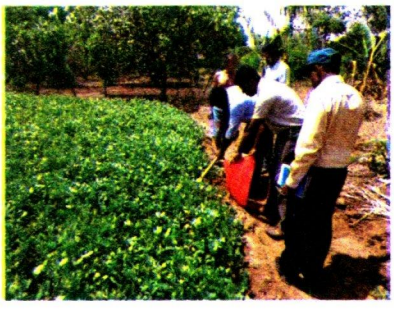
Field work with farmers at Padaviya

Field workshop at Maha Illuppallema

With Wayamba Provincial Minister of Agriculture

Field visit to Jaffna

Visit to Vavuniya



Groundnut cultivation at Kilinochchi

Department of Botany, University of Peradeniya, the Head of the Department of Microbiology, University of Kelaniya and the Manager, Agricultural Research & Development from Plenty Foods, a private company which has collaborated with us during the past 7 years. It updated the knowledge of the participants on this important group of microorganisms and provided skills development on the latest techniques for their use in crop production. This program was funded by the Crawford Fund, the Australian Council for International Agricultural Research and the Kirk House Trust of U.K.

Group photo of the Master Class on Root Nodule Bacteria

7. **Large scale culture of *Spirulina* as a low input, self supporting venture in backward villages of Sri Lanka in collaboration with the Mahatma Gandhi Center (MGC), Colombo**

IFS scientists: Prof. S. A. Kulasooriya, Dr. D. M. Magana-Arachchi and Dr. Ruvini Liyanage. Collaborators: Mr. Arjuna Hulugalle and Major General (retired) Kamal Fernando, Mahatma Gandhi Center (MGC), Colombo.

General Fernando of Swayang Wattegedera Ltd. submitted an application entitled "To grow the alga Spirulina to overcome malnutrition of children and pregnant & lactating mothers in villages of Sri Lanka" to the National Science Foundation under their Technology Grant scheme with the IFS as the Institutional partner. Having invited to make a presentation his proposal was short listed for further consideration. A few queries raised by the evaluating panel of the NSF on the nutritive quality, contamination with possible pathogenic bacteria and toxin production by *Spirulina* were answered after reference to the IFS. The grant was awarded on 17th December 2012. Currently laboratory level cultures of *Spirulina* are being maintained at the IFS and at Wattegedera Village Center of the MGC.

8. **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, MU.

The participating research students from IFS are: Mr. N. B. Suriyaarachchi and Mr. T. B. Nimalsiri.

The program is ongoing but progress has been limited as the student from the IFS earmarked to go to Thailand was on overseas leave for the past six months.

9. **Radon mapping project in collaboration with the AEA Sri Lanka**

IFS scientist: Dr. Deepal Subasinghe. Collaborators: Mr. Prasad Mahakumara, Senior Scientific Officer, AEA and Prof. T. Iimoto, NIRS, Tokyo University.

The first set of passive radon detectors donated by the NIRS was installed at predetermined locations. At the end of the required time period these detectors with the recorded data were sent to Japan for analysis. Prof. Iimoto visited Sri Lanka with an in-situ radon detector to check the radon levels and the accuracy of the passive radon detectors. Raw data has been sent back to Sri Lanka. Second phase of the project will be conducted in 2013.

Agreements were signed for the following new projects with:

- Plenty Foods (PVT) Limited, to extend MMBF studies to maize, legume pulse crops and other cereals grown by their out sourced farmers.
- The Atomic Energy Authority of Sri Lanka for the application of isotopes to conduct basic studies to understand the functioning of mutli-microbial inoculants in association with targeted crop plants. Studies on the use of gamma irradiation for the sterilization of carrier material of inoculants are also included.
- Kurunegala Plantations PLC to conduct studies on the application of multi-microbial inoculants in coconut plantations.
- Ambewela Livestock Company Ltd for the application of rhizobial inoculants to improve nitrogen fixation in clover used for their pastures, application of multi-microbial inoculants for grass mixed swards in pasture lands and rapid decomposition of their silage using microbial inoculations.
- Aquinas University (Pvt) to commence special student's projects on the application of multi-microbial inoculants for a variety of food crops.
- Atomic Energy Authority of Sri Lanka for a radon mapping project in collaboration with National Institute of Radiological Sciences and Tokyo University, Japan.

Most of these agreements were signed during the last few months and research results if any, are presented in the report of the Microbial Biotechnology Unit.

09. AWARDS, RECOGNITIONS AND PATENTS 2012

1. **Prof. M.A.K.L. Dissanayake** was an invited speaker and a chiar person at the following international conferences:
   - 13th Asian Conf on Solid State Ionics (ACSSI-2012), 17 - 20 July 2012, Sendai, Japan.
   - First International Conference on Advanced Materials, Science and Engineering, (ICAMSE '12), July 01-04, 2012 Colombo, Sri Lanka.

2. **Prof. M.A.K. L. Dissanayake**, was the Chief Guest at the 2012 Annual Awards Ceremony of the National Physics Olympiads and National Astronomy Olympiads competitions organized by the Institute of Physics, Sri Lanka (IPSL) and held at University of Colombo on 23rd November 2012.

3. **Dr. M.C.M. Iqbal**
   Invited speaker:
   - Planet under Pressure conference, London, UK on 26-29, March 2012.
   - Keynote address at the Annual Research Symposium 2012 of the Uva-Wellessa University of Sri Lanka.

4. **Prof. U.L.B. Jayasinghe** (2012). – Invited Speaker –13th International Symposium on Natural Product Chemistry, 22nd-25th Sept. Karachi, Pakistan.

5. **Prof. U.L.B. Jayasinghe**, Chairperson - 23rd Sept (afternoon session), 13th International Symposium on Natural Product Chemistry, Karachi, Pakistan.

6. **Prof. U.L.B. Jayasinghe**, served as a Special External Examiner for a Ph.D. viva on Natural Products, 3rd July, University College Dublin, Ireland.

7. **Prof. U.L.B.Jayasinghe**, (2012). Invited Speaker –International Symposium on Drug Discovery, Sabaragamuwa University of Sri Lanka, Belihuloya, Sri Lanka, 5th Jan.

8. **Prof. U.L.B. Jayasinghe**, has been elected as a Fellow of the National Academy of Sciences Sri Lanka.

9. **Prof. N.S. Kumar** (2012). Invited Speaker - International Conference on Chemical Sciences (ICCS) – 2012 organized by the Institute of Chemistry Sri Lanka, 22nd June, 2012, Colombo.

10. **Prof. N.S. Kumar** (2012). Keynote Speaker - International Conference on Exploration of Biotechnology by Student Scholars and Research – 2012 with a theme: Stimulating the learners for research in Biotechnology", on 8th – 9th June, 2012 at Shridevi Institute of Engineering &Technology, Karnataka, India.

11. **Prof. N.S. Kumar** (2012). – Invited Speaker –13th International Symposium on Natural Product Chemistry, 22nd-25th Sept. Karachi, Pakistan.

12. **Prof. N.S. Kumar**, Chairperson –Sept. 24th (afternoon session), 13th International Symposium on Natural Product Chemistry, Karachi, Pakistan.

13. **Ms. Maduni Madanayake** was selected for a fellowship by Alexander von Humboldt (AvH) Foundation, Germany. This project was carried out at the University of Heidelberg and University of Humboldt in Berlin, Germany.

14. **D.N. Magana-Arachchi**
    Recognition - Invited Speaker to international conference
    International Conference on Recent Trends in Molecular Medicine. Sree Buddha College of Engineering, Pattoor, Kerala, India. 23rd - 24th February 2012

15. **Assoc. Prof. Rohan Senadeera** was an invited speaker and country representaive at 10th SEE Forum , Innovations fo sustainable and Secure Energy, Internationa Forum hld in Brunei Darussaam, 21-23, November, 2012.

16. At the AGM of the GSSL, **Dr N.D. Subasinghe** was elected as one of the two Co-editors of the Journal of the Geological Society of Sri Lanka.

17. **Prof. G. Seneviratne** was elected as a Fellow of the National Academy of Science of Sri Lanka.

18. **Dr. Meththika Vithanage** was selected and awarded as an Young Affiliate of the Third World Academy of Science held in Tianjin, China, September, 2012.

19. **Dr. Meththika Vithanage** presented an invited speech at the 1st International Conference in Nano Technology for Water Treatment, IIT-Madras, September, 2012.

20. **Dr. Meththika Vithanage** presented an invited speech at the Risk Assessment Conference in Korea, December, 2012.

21. **Dr. Meththika Vithanage** - Journal article published in Geoderma by Rajapaksha et al. (2012) has been cited as one of the most downloaded articles in 2012.

22. Invited Talks in International Conferences

    Dr. Vithanage, M., Y.S. Ok. From bullets to the environment; Pollution risk from the shooting ranges. Invited Talk. Risk Assessment Conference, Seoul, Korea. 5th December, 2012.
    Dr. Vithanage, M. Monitoring water pollution from open solid waste dump sites in Sri Lanka. Invited Talk by the Young Affiliates. 12th General Conference of the Third World Academy of Sciences. Tianjin, China. 18-21 September, 2012.
    Dr. Vithanage, M. S.S.R.M.D.H.R. Wijesekara, I.P.L. Jayarathna. Nanomaterials for landfill leachate treatment: The Sri Lankan perspective. Invited Talk. First International Conference on Emerging Technologies for Clean Water. IIT-Madras, 14-16 September, 2012

23. **Ms. R.P. Wanigatunge**
    "Meeting of TWAS Fellows and TWAS Young Scientists" conducted by TWAS Regional Office for Central & South Asia (TWSAS- ROCASA) At: Jawaharlal Nehru Centre for Advanced Scientific Research, India on 15th- 17th November, 2012.

24. **Science Dissemination Unit** - In the National competition for best e- content (e-Swabhimani 2012), Vidumanpetha Sinhala Science web site was awarded with the Grand Jury special merit award under the category of e- Education & Learning on 10.01.2013.

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 public understanding of Science and improve the enthusiasm and interest of teachers, students and the general public about science

A. Foster the exchange of technical and scientific information for the scientific community **(Workshops, Conferences, Training Programme, Special Lectures)**

A.1 ***Workshops and Conferences***

i) 03.02.2012	Workshop on "How to Enhance Research Activities" by *Prof. D. M. Galloway, UK* for Research Assistants (22 participants).
ii) 28.06.2012 29.06.2012	Workshop on Solar Photovoltaic Technology-"Current status and Trends in Thin Film Solar PV Technology" organized by *Prof. M. A. K. L. Dissanayake, IFS* in collaboration with the Sivananthan Laboratories, Inc., USA and NSF, Sri Lanka (82 participants : Scientists, Engineers and M.Phil/Ph.D Research students from the Universities/Research Institutes/Other State and Private Sector Organizations)

A.2 ***Training Programme***

12.09.2012	" In house training workshop on "Impedance Spectroscopy" Methrohm Pvt Ltd through their local agents (Analytical Instruments Pvt Ltd) to provide in-house training to Research Assistants working on technologically important materials under the guidance of *Prof. M. A.K. L.Dissanayake)*

A.3 ***Special Lectures***

04.01.2012	**"Science and Civilization of Sri Lanka"** *Eng. T. Arumugam, Australia*
01.02.2012	**"Research commercialization - My Experience with Medical Device Industry in the Global Setup"** *Dr. Shirantha Samarappuli, VP-Regulatory Affairs & Quality Assurance, Circle Cardiovascular Imaging Inc., Canada*
03.02.2012	**"How to Enhance Research Activities"** *Prof. D. M. Galloway, UK*
15.02.2012	**"Ballast Water Treatment, Can you take the Challenge?"** *Dr. Nadeeshani Nanayakkara, IFS*
23.02.2012	**"Structure property relationship of ionic liquids and their Li-salt mixture"** *Mr. Jagath Pitawala, Chalmers University of Technology, Sweden*
29.02.2012	**"Quarks and Leptons - Are they the building blocks of nature?"** *Prof. M.A.K.L. Dissanayake, IFS*
21.03.2012	**"A plant under pressure"** *Dr. M. C. M. Iqbal, IFS*
06.06.2012	**"Psychological Assistance after a Large Scale Natural Disaster"** *Prof. Jianxim Zhang, Professor of Psychology, Institute of Psychology, China*

27.06.2012 **"Design and Development of Degradable Polymeric Nanoparticles for Nano medicinal Applications in Chemotherapy and Gene Delivery"**
Miss Sandani Samarajeewa, Departments of Chemistry and Chemical Engineering, Texas A&M University

24.07.2012 **"Readings and Dialogue"**
Ms. Namita Gokhale, Indian Author & Founder-Director of the Jaipur Literary Festival (Indian High Commission jointly organized with IFS)

27.07.2012 **"The Search for Earth-like Planets around other stars"**
Prof. Thulsi Wickramasinghe, Department of Physics, University of Peradeniya

25.07.2012 **"What Our Universe is made of"**
Prof. A. Nanayakkara, IFS

04.09.2012 **"Measures against Elevated Ambient Radiation Dose after Fukushima Disaster"**
Dr. *Takeshi Iimoto, National Institute for Radiological Sciences, Japan*

17.12.2012 **"Superconductivity: From Fascinating Physics to Flying Trains"**
Prof. M. A. K. L. Dissanayake, IFS

A. 4 Research meetings

Research meetings were conducted by the Research Assistants of the IFS. These meetings provide a platform to present research findings and discuss research problems with peer groups.

22.02.2012 **"Drinking Water Quality Assessment towards Chronic Kidney Disease of Unknown Etiology (CKDU), in Rajarata Area"**
Ms. H. M. Wasana, Research Assistant, IFS

14.03.2012 **"Removal of Aqueous Chromium by Non-Living *Cabomba caroliniana*"**
Mr. D. Chathuranga, Research Assistant, IFS

16.05.2012 **"Chemistry and Bioactivities of seeds of *Pouteria Campechinana* (Lavulu) and associated Fungi"**
Ms. G. Padmathilake, Research Assistant. IFS

22.05.2012 **"Design of a Portable Sinhala Text to Speech System"**
Mr. S.H.D.P.Wijethunga, Research Assistant, IFS

06.06.2012 **"Seasonal Variation of Water Quality and Plankton of Lake Gregory"**
Ms. M.B.U. Perera, Research Assistant, IFS

13.06.2012 **"Dye Sensitized Solar Cells Based on Sno2 and Zno Nanostructures"**
Mr. W.M.K T. Wijeratne, Research Assistant, IFS

22.08.2012 **"Single Bubble Sonoluminescence"**
Mr. H. M. P. S. Herath, Research Assistant, IFS

19.09.2012 "Investigation of Brain Activities due to new Mental Tasks using Common Spatial Patterns"
Ms. S.S. Zahmeeth, Research Assistant, IFS

10.10.2012 "Genetic Variation of Genus *Dendrobium* (Orchidaceae) in Sri Lanka"
Ms. P.M.H. Sandamal, Research Assistant, IFS

17.10.2012 **"Cluster Computing in Scientific Research"**
Mr. I.S. Karunawansha, Research Assistant, IFS

31.10.2012 **"Cowpea Incorporated Experimental Diets Reduce Serum Lipids in Rats"**
Ms. O. S. Perera, Research Assistant, IFS

14.11.2012 "Mechanisms Study: Anodic Oxidation of Phenol in Contaminated Water on Dimensionally Stable Anode"
Ms. B. Jayatilake, Research Assistant, IFS

B. Promoting Public Understanding of Science

B.1 Exhibition - 21st - 23rd September 2012 - 43rd Dr C.W.W. Kannangara Memorial Programme, Hadunu Wewa Central College, Kotmale

B.2 Educational Lecture (10.01.2012) on Nano technology for students (400 students) from Dhammeesara Madyamaha Vidyalaya ,Naththandiya. Funded by Science Rays (ViduKirana) Project.

B.3 Workshops:

i) Four workshops were held on "Effective use of Microbial Biofertilisers for an Improved Economy and Environment in Sri Lanka " for extension officers and farmers on 23.02.2012, 06.03.2012, 15.03.2012 & 05.04.2012 (70 participants).

ii) Workshop on "Effective use of Microbial Biofertilisers for an Improved Economy and Environment in Sri Lanka" for Managers of " Krushi Sewa Piyassa" (20 participants) held on 23.08.2012.
Co-organizers of the workshops - Prof. S. A. Kulasooriya , Prof. Gamini Seneviratne

iii) Workshop on "Nano Science and Nano Technology" for teachers and students:

04.05.2012	Workshop on Nano Science for teachers (30 participants) of the Kotmale Educational Zone.
30.05.2012	Grade nine students (200) and teachers from Halawatha Senanayake Madyavidyalaya, Madampe.
21.06.2012	Grade 6 – 11 students (300) from A/Aliwanguwa Maha Vidyalaya, D10 Mithri Vidyalaya and Padavi Parakrama Vidyalaya in Padavisripura. SDU donated science kits for teachers & students. Funded by Science Rays (ViduKirana) Project.
06.07.2012	Grade 9 students (150) from Madurankuliya MahaVidyalaya. SDU donated science kits for teachers & students. Funded by Science Rays (ViduKirana) Project.
11.09.2012 & 13 09.2012	Grade 9 students (300 students) from Poramadulla Central College. SDU donated science kits for teachers & students.
02.10.2012	Students (120) from Weera Parakrama Central College, Yatawatha.
12.11.2012	G.C.E. O/L students (62) of Udagama, Walimada. SDU donated science kits for teachers & students. Funded by Science Rays (ViduKirana) Project and Rotary Club, Kandy.
04.10.2012	Year 11 students (150) from Kotmale educational zone. SDU donated science kits for students . Funded by Science Rays (ViduKirana) Project.

39th School Science Programme 2012 (SSP)
18 – 21 December, 2012

The School Science Programme (SSP) is one of the most important programmes conducted annually for the dissemination of science among the younger generation. This programme is conducted to bring together bright young minds from diverse regions in the country to promote thinking, imagination, curiosity, wonder and excitement for new ideas and discoveries. Since the inception of this programme in 1987, a total of 2997 students, who have excelled at the GCE (Ordinary Level) examination, have

participated in this activity. There were 137 students for the 2012 programme. Students of varied ethnic, religious and economics backgrounds were selected for this programme to encourage understanding and to respect the differences between themselves as individuals.

B.4 Laboratory Training and Visits to the IFS

1. Students (70) from Visaka Vidayalaya Colombo – visited the Molecular Biology Laboratories. (06.03.2012)
2. Students (75) from Rippon Balika College, Galle, visited IFS laboratories (08.06.2012)
3. B. Sc. General Degree students (40) of the Faculty of Applied Sciences, Rajarata University of Sri Lanka, visited the Microbial Biotechnology Laboratory, as part of the course unit BOT 3106 – Biological Nitrogen Fixation and its Applications (29.11.2012).
4. B. Sc. Students (30) (Microbiology – Biochemistry – Biotechnology) from "Spectrum Institute of Science and Technology", Colombo visited the IFS as a part of the compulsory industrial visit prescribed for the University of Mysore Syllabus.(30.11.2012)

B. 5 Science website in Sinhala

B.6 Science Youtube service

IFS official Channel launched on 03.11.2012

Publishing videos of IFS special events, such as lectures and workshops, to build up an active on line audience.

Vidu Nena Dasuna Channel launched on 26.03.2012

Producing videos about scientific matters related to O/L and A/L syllabus. Subject matters were selected based on the requests of students and teachers.

B.7 VIDU NENA HAWULA e-project *launched on 02.01.2012*

Free of Charge

To the best of our knowledge, this is the very first programme of this nature in South Asia.

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

SMS sent to registered participants every day except on government holidays.
Members also received one question and answer per week.
As the name "Vidu Nena Hawula" itself explains, it is an open forum for the subscribers to discuss problems, related to science behind day to day activities, with the scientific community.

B.8 Science blogs launched on *12.01.2012*

The SDU is also publishing science articles in Sinhala to provide more information on interesting science concepts

B.9 Science Dissemination through Social Media

A. Facebook

Institute of Fundamental Studies official facebook page was initiated on *03.01.2012*

1. Informing the general public about the public lectures and special lectures.
2. Broadcasting important IFS news

B. Vidu Nena Hawula facebook page initiated on *13.06.2012*

C. Face book Groups

Vidu Nena Hawula face book group

Providing an area for students and the general public to discuss scientific matters and ask questions.

School Science face book group

Providing an opportunity for SSP participants to be in contact with the IFS and among themselves.

D. Twitter

IFS official profile initiated on 03.11.2012

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

Vidu Nena Hawula profile initiated on 17.07.2012

Letting the general public subscribe and receive science news.

E. Blogger with Google+ initiated on *12.01.2012*

IFS official Google+ profile

Vidu Nena Hawula Google+ profile

10.2 Dissemination of Science by Research Groups

a) Dissemination of Science by Condensed Matter Physics and Solid State Chemistry group

Workshop on Current Status and Future Trends in Thin Film Solar PV Technology, co-organized by the IFS and NSF and held at the IFS, Kandy on 28th and 29th June, 2012

Developing a trained workforce of scientists, engineers and technicians competent in alternative energy technologies has become a timely need and a responsibility of universities and research institutes. In order to contribute toward this, the Institute of Fundamental Studies, in collaboration with the Sivananthan Laboratories, Inc, USA and National Science Foundation, Sri Lanka organized a two day workshop on *Solar Photovoltaic Technology* on 28th and 29th June 2012 at the IFS auditorium. 80 participants representing university Professors, Engineers, Lecturers and M.Phil./Ph.D. postgraduate research students from Science and Engineering disciplines from universities and private sector agencies attended the workshop.

The workshop was coordinated by Prof. Lakshman Dissanayake, Research Professor at IFS and was conducted by Dr. S. Sivananthan, Dr. Tim Coutts, Dr. Ramesh Dhere and Dr. Chris Grien from the Sivananthan Laboratories, Inc., Bolingbrook, IL, USA under the guidance of Prof. Siva Sivananthan, University of Illinois at Chicago and Sivananthan Laboratories and Prof. C.B. Dissanayake, Director of the Institute of Fundamental Studies, Kandy.

This activity was a part of building up a R&D potential in Sri Lanka on solar PV technology, initiated through the Gobal Forum conference organized by the NSF in December 2011.

The two day workshop covered topics from basics of photovoltaic science and technology to applications largely focused on thin film solar cells. Special emphasis was made on the next generation of high efficiency and low cost Cde based thin film solar cells. On the first day, Professor S. Sivananthan, Founder and CEO of Sivananthan Laboratories, Inc., USA highlighted the importance of providing training to young scientists and engineers on solar PV technology as Sri Lanka will in the near future embark on the utilization of solar energy for meeting a part of her energy needs.

A book of handouts containing power point presentations by all the resource persons was distributed to all the participants.

b) Presentations by Microbial Biotechnology Group

Seneviratne, G. (2012) Microbes and sustainability of agroecosystems. Extension workshop conducted at Field Crops Research and Development Institute, Maha Illuppallama. 23 February 2012.

Seneviratne, G. (2012) Biofilmed biofertilizers: an ecosystem approach. Rice Research and Development Institute, Batalagoda. 27 March 2012.

Seneviratne, G. (2012) Trends in improving microbial inoculants. Workshop conducted for Officers of the Plenty Foods (Pvt.) Ltd. IFS. 5 April 2012.

Kulasooriya, S. A. (2012) Biofertilizers to improve soil health. Workshop conducted for Officers of the Plenty Foods (Pvt.) Ltd. IFS. 5 April 2012.

Seneviratne, G. (2012) Multi-microbial biofertilizers: novel biofertilizers. Workshop conducted for *Govi Piyasa* Managers of AgEDIS, Department of Agriculture. IFS, 23 August 2012.

Kulasooriya, S. A. (2012) Biofertilizers for low cost, environmentally friendly Agriculture. Workshop conducted for *Govi Piyasa* Managers of AgEDIS, Department of Agriculture. IFS, 23 August 2012.

Seneviratne, G. (2012) Reinstating soil microbial diversity in conventional agriculture: the need of the hour for sustainability and health. NASSL Fellowship Presentation. Colombo. 21 September 2012.

Kulasooriya, S. A. (2012) Application of biological nitrogen fixation in Agriculture and Forestry. Students of the Faculty of Science, Rajarata University of Sri Lanka, IFS, 12.

c) Other events

Dr. Dittus - School Science Program, 21st December 2012. Lecture on Primate behavior, ecology and conservation.

International Documentary Films: The Primate Biology groups 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 2012 these were as follows:

- BBC Natural World (UK). "Planet Earth Live" April-May 2012.
- Discovery Channel (USA): "Wildest Islands" (Off the Fence Productions), June 2012
- Disney Productions (USA): "Jungle Stories" (Jungle Bear Productions, UK). July to October, 2012.

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

The Library provides the following Technical and Reference Services to users of the library :

- 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	Data on public works	Sri Lanka Collection
Photographs	Newspapers	Electronic materials
Architectural documents	Text and Ephemera	Biographies
Correspondence	Special Collections	M.Phil. and Ph.D. theses
Government documents	Directories	Maps, Posters

Present collection of the IFS library

Collection	Added during 2012 January-December	Total as on 31st December 2012
Books	182	6400
Theses	8	103
CDs	14	368
Maps	10	479
Reports	21	505
Subscription to journals Exchange	12	>1000
journal	14	>1000
Reprints	11	713
New papers articles	86	86

Leading multidisciplinary journals are available such as *Nature, Science, New Scientist* etc., providing the latest information on a variety of disciplines. The Library also provides access to the Online Access to Research in the Environment **(OARE),** data base through subscription. OARE provides online access to one of the world's largest collections of environmental science research over 4,150 peer-reviewed scientific journal titles owned and published by over 350 publishers.

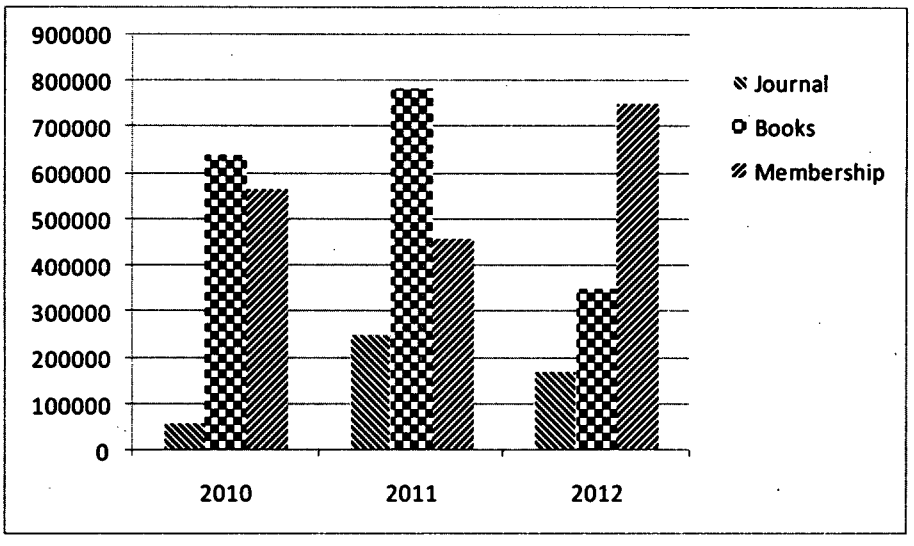
The Library provides online subscriptions to specialized journals to individual scientists. Currently 40 specialized journals are available online through this scheme.

Library Network

Member of the Sri Lanka Scientific & Technical Information Network (SLSTINET) and Agricultural Information Network (AGRINET).

Training Programme

1. "Introduction to eLibrary USA" Organized by the IFS Library. Lectures were conducted by Mrs. Padma Bandaranayake, Library Director, American Center, Colombo.
2. Library training was given to the newly appointed librarian at the Indian High Commission, Kandy, one Library Association student and a NAITA student.



Budget allocation (Rs) for 2010- 2012

Conference attended

National Conference on Library and Information Science. (NACLIS) 2012. "Empowering Users, Libraries and Librarians in the Knowledge Society." 21st June 2012.

Conference Grants

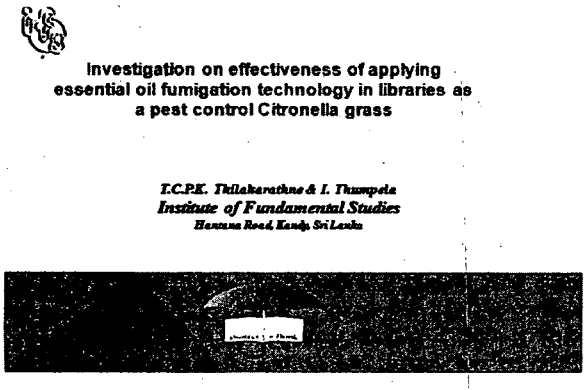
Received a conference grant from "Conference on Library and Information Science" (NACLIS) 2012.

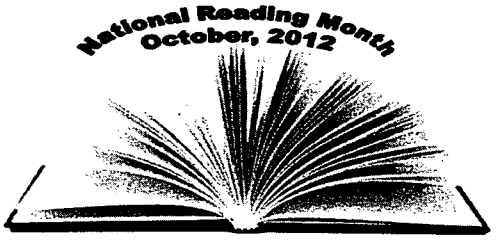
Current Research

Investigation on effectiveness of applying essential oils fumigation technology in libraries for pest control using Citronella grass: *Cymbopogon nardus*. T.C.P.K. *Tilakarathna and I. Thumpela,* The proposal was submitted to the Elsevier Foundation, and was placed in top 40 out of 400 proposals (January 06th 2012).

The Library provided assistance to prepare the IFS Self-Assessment report 2009-2011 submitted to the National Science and Technology Commission.

The Library has also prepared an Index of the Institute of Fundamental Studies Journal Collection 1932-2010





Other Activities

- Made presentation on "Improving reading habits in children and introduction of library system".

  Liyangaswagura Adarsha Kanishta Vidyalaya, Panwila, Kandy- October 17, 2012. (Participation 150 Students)

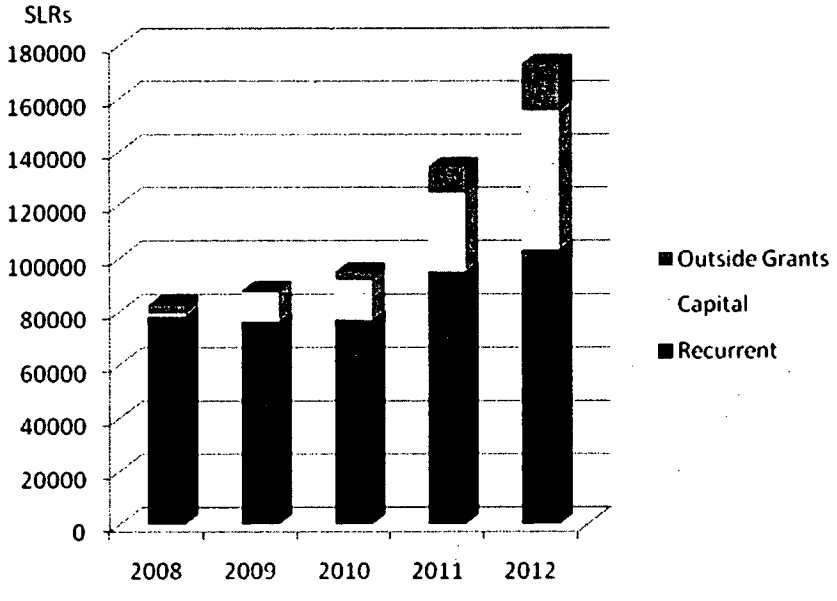
  Kegalle Balika Vidyalaya, Kegalle, October 30, 2012. (Participation 500 Students)

- Provide Library training to the teachers at Hemamali Balika Vidyalaya, Kandy on "How to Organize School Library with Dewey Decimal System", July 2012.

12. BUDGET

Total Annual Expenditure (Rs. '000)

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



Total Annual Expenditure for the past five years

13. IFS STAFF NEWS – 2012

13.1 Recruitments

The following staff were recruited to the IFS during 2012

1.	Mr. P.S.B. Wanduragala	-	Secretary/IFS
2.	Mr. Manjceevan	-	Research Assistant – Grade II
3.	Ms. S.S. Mayakaduwa	-	Research Assistant – Grade II
4.	Mr. C.S. Jayasinghe	-	Research Assistant – Grade II
5.	Mr. E.M.H.G.S. Ekanayake	-	Research Assistant – Grade II
6.	Ms. A.G.D.D. De Silva	-	Research Assistant – Grade II
7.	Ms. R.D.W.C. Rajapaksha	-	Administrative Officer
8.	Ms. R.H.G. Saranga	-	Internal Auditor
9.	Mr. M.K.D. Keshan	-	Management Assistant Grade III
10.	Ms. T.P. Gamalath	-	Management Assistant Grade III

13.2 International/National Committees

Prof. M.A.K.L. Dissanayake continued to serve as a member of the Board of Governors of the Institute of Fundamental Studies (IFS).

Prof. M.A.K.L. Dissanayake continued to serve as a member of the Board of Management of the Postgraduate Institute of Science (PGIS), University of Peradeniya.

Prof. M.A.K.L. Dissanayake served as the Chairman of the Research Panel on Basic Sciences of the National Science Foundation.

Prof. M.A.K.L. Dissanayake served as a member of the International Partnership Committee of the National Science Foundation.

Prof. M.A.K.L. Dissanayake served as an outside member of the Faculty Board of Science, University of Peradeniya.

Dr. Dittus is a member of the Committee for the National Red List, Biodiversity Secretariat, Ministry of the Environment, Government of Sri Lanka.

Dr. Iqbal, Member of the editorial board of the Ceylon Journal of Science.

Dr. Iqbal, Member of the General Research Committee of the SLAAS.

Prof. U.L.B. Jayasinghe, Member, Faculty Research Committee, University of Peradeniya.

Prof. U.L.B. Jayasinghe, Coordinator, Postgraduate Certificate Course in Advanced Organic Chemistry, PGIS, University of Peradeniya.

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 published by Elsevier.

Dr. N.D. Subasinghe - Executive Committee Member - Geological Society of Sri Lanka.

Dr. N.D. Subasinghe - Co-Editor – Journal of the Geological Society of Sri Lanka

Dr. C.T.K. Tilakaratne continued to serve as a member of the National Committee on Science Popularization NSF.

Dr. Vithanage served the Committee on International Participation of the American Geophysical Union during the AGU Fall Meeting at San Francisco, USA, Dec, 2012.

Dr. Vithanage invited to serve as a committee member at the Biochar Special Session of the Solid Waste Conference 2013 in Hong Kong.

Dr. Vithanage was invited to serve in the Editorial Board of the Journal of Agricultural Chemistry and Environment (JACEN).

Dr. Vithanage was invited to provide her expertise as an International Adviser to the 15 million USD granted project on antibiotic pollution from carcass disposal sites in Korea.

13.3 Participation in international/national Workshops/Training programs/Seminars by personnel in projects

Prof. M.A.K.L. Dissanayake participated as an invited speaker and presented a research paper at the MRS 2012 Spring Meeting held in San Francisco, USA from 9th to 13th April, 2012

Prof. M.A.K.L. Dissanayake visited the Sivananthan Laborotries, Inc., USA from 16th to 22nd April, 2012to engage in an R&D project on CdTe solar cells.

Prof. M.A.K.L. Dissanayake participated as an invited speaker and presented research paper at the 13th Asian Solid State Ionics Conference (ACSSIS-2012) held in Sendai, Japan from 18th to 21st July 2012.

Prof. M.A.K.L. Dissanayake visited the Polymer Research Laboratory at Chalmers University of Technology, Gothenburg, Sweden from 5th to 15th November, 2012.

Dr. G.K.R. Senadeera participated as an invited speaker and presented a paper at the 10th SEE FORUM , Innovations for Sustainable and Secure Energy, held in Brunei Darussalam from 21-23 November 2012.

Dr. G.K.R. Senadeera participated and presented a paper at the International Symposium of "Sustainable Future Energy 2012", held in Brunei Darussalam from 21-23 November 2012.

Dr.G.K.R. Senadeera participated and presented research findings at Biannual Research Forum, Faculty of Natural Sciences , The Open University of Sri Lanka, 17th May 2012 .

Ms. W.N.S. Rupasinghe, Research Assistant, spent three weeks carrying out a research project at the Center for Ionics, University of Malaya, Kuala Lumpur, Malaysia from 1st to 20th July 2012.

Mr. N.B. Suriyaarachchi, Research Assistant, attended 6 month training course on geothermal and geophysical techniques in Reykjavík, Iceland, under United Nations University Fellowship programme.

Dr. N.D. Subasinghe, Senior Research Fellow, participated in the "5th Asian School on Renewable Energy: Advanced Micropower Systems" held at *Universiti Kebangsaan Malaysia (UKM),* Selangor, Malaysia from July 9 - 13, 2012.

Dr. N.D. Subasinghe attended the International Conference on Civil, Architectural and Hydraulic Engineering (ICCAHE 2012), Zhangjiajie, China in August 2012 and presented the paper titled "Locating of salt and freshwater interface in coastal zones using 2D resistivity imageries". This paper was selected for publication in the international journal *Applied Mechanics and Materials.*

R.R. Ratnayake, T. Kugendran, N. Gnanavelrajah (2012). Assessment of soil Carbon stocks under different agricultural management practices in the tropics. *International Conference on Soil Science and food security,* British Society of Soil Science, University of Nottingham, UK, 4th- 5th September 2012.

R.R. Ratnayake (2012). Bio-degradation of lignocelluloses for biofuel Production. *The 5th Asian School on Renewable Energy: Advanced Micropower Systems.* National University of Malaysia, Malaysia 9th – 13th July 2012.

R.R. Ratnayake, D. Wasalamuni, T. Gunaratne, (2012). Potential of soil carbon sequestration in home gardens of the Central Province. *International conference on Agro Biotechnology for sustainable development*, Colombo, Sri Lanka. 13th March 2012.

R.R. Ratnayake. Participated for the Panel of judges for the Science and Technology Session, Research Symposium, Uwa Wellassa University.

G. Seneviratne, H. M. L. I. Herath, U.V.A. Buddhika, N. Weeraratne – Participated in Aus AID PSLP Agreement 58648: Workshop on effective use of microbial fertilisers for an improved economy and environment in Sri Lanka (PSLP Workshop 2) and 16th Australian Nitrogen Fixation Conference, University of Sydney, Australia, June 17-July 1, 2012.

N. S. Kumar - *Workshop on Intellectual Property Rights (IPRs) for Innovations And Development.* May 8-10, 2012, Galadari Hotel, Colombo, organized by the Alumni Association of International Development Law Organization (IDLO), Sri Lanka under the aegis of the IDLO, Rome, Italy

A.G.A.W. Alakolanga, A.M.D.A. Siriwardena, S.M.S.K.H. Bandara, G.G.E.H. De Silva, D.S. Jayaweera, N.S.Kumar, U.L.B Jayasinghe participated in *the International Conference on Chemical Sciences (ICCS) – 2012* organized by the Institute of Chemistry Sri Lanka, 22nd -25th June, 2012, Colombo.

N.S. Kumar, AASA/NASSL Symposium on *Science Communication Leadership Program.* Colombo, October 17, 2012.

G.G.E.H. De Silva, *A Meeting of Young Scientists*, TWAS Young Affiliates & Fellows of TWAS in Central & South Asian Region, Jawaharlal Nehru Centre for Advanced Scientific Research, 15-17 Nov. Bangalore, India.

U.L.B. Jayasinghe, EUROMAR European Magnetic Resonance Conference – 2012, 1st – 6th July, Dublin, Ireland.

D.N. Magana-Arachchi.

- International Conference on Recent Trends in Molecular Medicine. Sree Buddha College of Engineering, Pattoor, Kerala, India. 23rd - 24th February 2012
- Workshop on 'Intellectual Property Rights (IPRs) for Innovations and Development - 08-10th May 2012. Organized by The Sri Lanka Alumini Association of the International Development Law Organization (IDLO).
- International symposium on "Water quality and human health: Challenges ahead" conducted by Board of Study in Zoological Sciences and Environmental Sciences, PGIS in collaboration with Toyama Prefectural University, Japan on 22nd- 23rd March, 2012, Sri Lanka
- "Inaugural conference of Sri Lanka Society for Microbiology" held at Postgraduate Institute of Science, University of Peradeniya, Sri Lanka, on 25th June, 2012.

R.P. Wanigatunge

- International symposium on "Water quality and human health: Challenges ahead" conducted by Board of Study in Zoological Sciences and Environmental Sciences, PGIS in collaboration with Toyama Prefectural University, Japan on 22nd- 23rd March, 2012, Sri Lanka
- "Inaugural conference of Sri Lanka Society for Microbiology" held at Postgraduate Institute of Science, University of Peradeniya, Sri Lanka, on 25th June, 2012.
- "Meeting of TWAS Fellows and TWAS Young Scientists" conducted by TWAS Regional Office for Central & South Asia (TWSAS- ROCASA) At: Jawaharlal Nehru Centre for Advanced Scientific Research, India on 15th- 17th November, 2012.

H.M. Liyanage

- Theme seminar on Chronic Kidney Disease in North Central Province, Sri Lanka conducted by Faculty of Graduate Studies in collaboration with Faculty of Medical Sciences, University of Sri Jayawardanapura, on 12th December, 2011, Sri Lanka

- International symposium on "Water quality and human health: Challenges ahead" conducted by Board of Study in Zoological Sciences and Environmental Sciences, PGIS in collaboration with Toyama Prefectural University, Japan on 22nd- 23rd March, 2012, Sri Lanka
- "Inaugural Conference of Sri Lanka Society for Microbiology" held at Postgraduate Institute of Science, University of Peradeniya, Sri Lanka, on 25th June, 2012.

D.K. Weerasekera

- Workshop on "Writing for Microbiology peer reviewed journals" organized by Kandy Society for Microbiology, Pathology Lecture Theater, Faculty of Medicine, University of Colombo, Sri Lanka, on 20th June, 2012.
- Workshop on "Use of Molecular Methods for the Diagnosis of Emerging Infectious Diseases; Hands on experience on DNA/RNA extractions, PCR and gel electrophoresis & lectures and discussions on protocols, concepts and troubleshooting", organized by Department of Microbiology and Department of Parasitology, Faculty of Medicine, University of Peradeniya, on 23rd- 24th June 2012, Sri Lanka
- "Inaugural conference of Sri Lanka Society for Microbiology" held at Postgraduate Institute of Science, University of Peradeniya, Sri Lanka, on 25th June, 2012.

Ms. S. Zahmeeth participated in a workshop on Biomedical Imaging and Instrumentation Systems on 28th July, 2012 organized by the Department of Electrical &Electronic Engineering, University of Peradeniya.

Mr. P. K. D. Chathuranga attended/submitted a paper for the following:

- International symposium on Water Quality and Human Health held at PGIS, Peradeniya on 22-23, March 2012.
- International conference, Planet Under Pressure held in London, UK on 26-29, March 2012.
- 5th International Congress of Environmental Research held in Kuala Terengganu, Malaysia on November 22-24, 2012.

Mr. P. K. D. Chathuranga

- Workshop on Ethics in Research held at Sri Lanka Association for Advancement of Science, Colombo on 20th April 2012.
- 18th Annual scientific sessions of the Sri Lanka Association for Fisheries and Aquatic Resources held in Colombo on 17-18, May 2012.
- Training programme on CHN analyzer held at IFS on 05th July 2012.

Ms. Maduni Madannayake
Climate Change Fellowship by the Alexander von Humboldt (AvH) Foundation, German, October 2011 to October 2012.

Dr. M.C.M. Iqbal
Planet under Pressure conference, London, UK on 26-29, March 2012.
Centre for World Environment History, University of Sussex, April 2012
Keynote address at the Annual Research Symposium 2012 of the Uva-Wellasa University.

Mr. S.S.R.M.D.H.R. Wijesekara and Mr. I.P.L. Jayarathna attended a workshop on Research Ethics, Developing a regulatory framework for nanotechnology related activities in Sri Lanka. National Science Foundation. 31th May 2012.

Dr. M Vithanage and Ms. RMAU Rajapaksha participated the mini workshop on the Environmental Consequences of Mercury and Related Compounds organized by the Ministry of Environment, June, 2012.

Dr. M Vithanage participated 2nd Workshop on the water safety from source to tap – strategies and implementations – Asia Pacific Network for global change research 22-24th February, 2012

J. Akilavasan delivered a lecture on " nanotechnology for better future" at school science program 2011 held at IFS.

W.M. K.T. Wijeratne participated and presented a research finding at the poster session in 1st conference " Physics and Development" Research in Physics – Physics Applications – Education – Held at Brussels, Belgium from 11-12 October, 2012.

W.M.K.T. Wijeratne and J Akilavasan participated the International Conference on Advanced Materials, Science and Engineering (ICAMSE) - Held at Galle Face Hotel, Colombo, Sri Lanka on July 2-3, 2012 and presented research findings at the oral sessions.

W.M.K.T. Wijeratne and J. Akilavasan for a Workshop on Current Status and Future Trends in Thin Film Solar PV Technology at Institute of Fundamental of Studies(IFS), Kandy, Sri Lanka, from 28-29 June 2012.

W.M. K.T.Wijeratne participated International Conference on the Energy and Materials Research (EMR 2012)- Held at Torremolinos Congress Centre, Torremolinos, Malaga, Spain, from 20th to 22th June 2012 and presented research findings at the oral session.

H.A.P.P.B. Jayathilake
Symposium on "The Potential Health and Environmental impacts of exposure to hazardous natural and man-made chemicals and their proper management" (Organized by the Centre for Environmental Justice (CEJ) in collaboration with the Department of Zoology, University of Sri Jayawardhanapura) , Colombo City Hotel, Colombo, Sri Lanka, 22-23 November 2012.

C. Weerakkody
Symposium on "The Potential Health and Environmental impacts of exposure to hazardous natural and man-made chemicals and their proper management" (Organized by the Centre for Environmental Justice (CEJ) in collaboration with the Department of Zoology, University of Sri Jayawardhanapura) , Colombo City Hotel, Colombo, Sri Lanka, 22-23 November 2012.

G. C.Pathiraja
Symposium on "The Potential Health and Environmental impacts of exposure to hazardous natural and man-made chemicals and their proper management" (Organized by the Centre for Environmental Justice (CEJ) in collaboration with the Department of Zoology, University of Sri Jayawardhanapura) , Colombo City Hotel, Colombo, Sri Lanka, 22-23 November 2012.

P. W. Abeygunawardhana
Symposium on "The Potential Health and Environmental impacts of exposure to hazardous natural and man-made chemicals and their proper management" (Organized by the Centre for Environmental Justice (CEJ) in collaboration with the Department of Zoology, University of Sri Jayawardhanapura) , Colombo City Hotel, Colombo, Sri Lanka, 22-23 November 2012.

N. Nanayakkara
International conference on sustainable built environment, Earl's Regency Hotel, Kandy, Sri Lanka, 14-16 December 2012.

13.4 Visits by IFS Scientists

Dr. M Vithanage participated as a visiting research scientist for a collaborative research program at the Department of Biological Environment at Kangwon National University, Korea from 15th August to December 31st, 2012.

Dr. R. Ratnayake visited Food and Biofuel innovation centre, University of Nottingham, UK.

J. Bandara visited Germany to conduct research on solar cells in 2011.

13.5 Research grants received during 2012

Prof. J.M.S. Bandara
Received two NSF research grants in 2012

Prof. C.B. Dissanayake and **Prof. Lakshman Dissanayake** received an Equipment Grant of **Rs. 576,000** from the National Science Foundation to be used for research on polymer electrolytes and other materials.

Prof. Lakshman Dissanayake received a three year Research Grant of **Rs. 2.8 Mn** from the National Science Foundation for a research project on CdS based solar cells.

Prof. U.L.B. Jayasinghe, Prof. N.S. Kumar
From National Science Foundation Sri Lanka (RG/2012/AG/01)
"Chemistry and Bioactivity of some popular edible fruits: Studies on possible application in health and agriculture"
Rs. 1,870,964.00

Prof. N.S. Kumar, Prof. U.L.B. Jayasinghe
From National Science Foundation Sri Lanka (RG/2012/BS/06)
"Bioactive molecules from endophytic microorganisms associated with medicinal and allelopathic plants from Sri Lanka"
Rs. 1,148,200.00

Prof. N.S. Kumar, Prof. U.L.B. Jayasinghe
From National Research Council – Sri Lanka (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. 5,425,000.00

Dr. Kumudu Perera (University of Peradeniya), Prof. U.L.B. Jayasinghe
From National Science Foundation Sri Lanka (RG/2012/BS/01)
"Identification and isolation of potential antidiabetic compounds from Sri Lankan medicinal plants"
Rs. 1,306,000.00

Dr. R. Liyanage - Co-Investigator-"Development of Household food security models for poverty stricken areas of Sri Lanka". National Thematic research program food security-2012, National Science Foundation, Sri Lanka.

Dr. K.G. N. Nanayakkara - Two research grants, received in 2011, are currently in-progress

- National Research Council (Sri Lanka) Grant number 11-054: Development of electrochemical technologies to remove organic and heavy metal pollutants present in pesticides.
- National Science Foundation (Sri Lanka) Grant number RG/2011/BS/01: Development of an electrochemical technology to remove nitrate from contaminated groundwater.

Dr. R.R. Ratnayake - NRC grant: 12-031, National Research Council, Rs. 5,945,027.00 : Biofuel and other microbial products from cellulosic biomass.

Dr. N.D. Subasinghe - A research grant of Rs. 2,060,063.00 was awarded by the National Science Foundation (NSF) to conduct the research project "Estimate subsurface extension of Eppawala apatite deposit and its parent rock using geophysical techniques".

Prof. R. Weerasooriya
Development of unit processes for chemical removal of nitrates –funds approved by NRC Sri Lanka

14. PUBLICATIONS OF IFS MEMBERS - 2012

14.1 Publications in refereed journals

1. Almaroai, Y., Usman, A.R.A., Ahmad, M., Kim, K-R., **Vithanage, M.**, Ok, Y.S. Role of chelating agents on desorption kinetics of metals (Cu, Cr and As) and their uptake by Zea Mays L. From a contaminated soil (In press, *Environmental Technology*).

2. Aydin, M., **Vithanage, M.**, Mowjood, M.I.M., Jung, Y., Yang, J.E., Ok, Y.S., Kim, S.C., **Dissanayake, C.B.** (2012). Estimation of evaporation and drainage losses from two bare soils in Sri Lanka. *Eurasian Journal of Soil Science*, 11 – 9.

3. Bandara, T.M.W.J., Svensson, T., **Dissanayake, M.A.K.L.**, Furlani, M., Jayasundara, W.J.M.J.S.R., Mellander, B.-E. (2012). Tetrahexylammonium Iodide Containing Solid and Gel Polymer Electrolytes for Dye Sensitized Solar Cells. *Energy Procedia, 14*, 1607–1612.

4. Bandara, T.M.W.J., **Dissanayake, M.A.K.L.,** Jayasundara, W.J.M.J.S.R., Albinssone, I., Mellander, B.-E. (2012). Efficiency enhancement in dye sensitized solar cells using gel polymer electrolytes based on a tetrahexylammonium iodide and MgI2 binary iodide system. *J. Phys. Chem. Chem. Phys.14*, 8620–8627.

5. Batuwita, S*., Pethiyagoda, R. (2012). Rediscovery of the Sri Lankan 'house gecko' *Hemidactylus pieresii* Kelaart (Reptilia: Gekkonidae) with a redescription of *Hemidactylus depressus* Gray. *Zootaxa 3359*, 17 – 30. (*Mr. Batuwita worked at the IFS until end of 2011).

6. Chandrajith, R., Barth, J.A.C., **Subasinghe, N.D.**, Merten, D., **Dissanayake, C.B.** (in press). Geochemical and isotope characterization of geothermal spring waters in Sri Lanka: Evidence for a steeper than expected geothermal gradients. *Journal of Hydrology. Vol. 476, (7),* 360-369. 2013

7. Chathuranga, P.K.D., Priyantha N., Iqbal S.S., **Iqbal M.C.M.** (2012). Biosorption of Cr(III) and Cr(VI) from aqueos solution by *Cabomba caroliniana*: kinetic and equilibrium study. *Environmental Earth Sciences.* Published online (DOI 10.1007/s12665-012-2150-9).

8. **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. (2012). Ionic conductivity enhancement in the solid polymer electrolyte PEO_9LiTf by nanosilica filler from rice husk ash. *J Solid State Electrochem*, DOI 10.1007/s10008-012-1737-0. *(Published Online, printed version to be released soon).*

9. **Dissanayake, M.A.K.L.,** Thotawatthage, C.A., Senadeera, G.K.R., Bandara, T.M.W.J., Jayasundera, W.J.M.J.S.R., Mellander B.-E. (2012). Efficiency enhancement by mixed cation effect in dye-sensitized solar cells with PAN based gel polymer electrolyte. *J Photochemistry & Photobiology: A Chemistry 246*, 29– 35.

10. **Dittus, W.P.J.** (2012). Family fortunes. *BBC Wildlife*, May 2012, 46-52.

11. **Dittus, W.P.J.** (2012). Problems with pest monkeys: myths and solutions. *Loris*(~~in press~~).

12. **Dittus, W.P.J.** (2012). An online forum for exchanging ideas for dealing with issues of pest monkeys. *J. Primatol. 1,* 1-2.

13. Herath, H.M.L.I., Senanayeke, D.M.N., **Seneviratne, G.**, Bandara, D.C. (2012). Variations of biochemical expressions of developed fungal-bacterial biofilms over their monocultures on plant growth. *Tropical Agricultural Research, 24* (in press).

14. Jaiswal, R., **Jayasinghe, L.**, Kuhnert N. (2012). Identification and characterization of proanthocyanidins of 16 members of the *Rhododendron* Genus (Ericaceae) by tandem LC-MS. *Journal of Mass Spectroscopy, 47,* 502-515.

15. Jayarathne, L., Ng, W.J., Bandara, A., **Vitanage, M.**, **Dissanayake, C.B.**, **Weerasooriya, R.** (2012). Fabrication of succinic acid-γ-Fe2O3 nano core–shells. *Colloids and Surfaces A: Physicochemical and Engineering Aspects, 403(0),* 96-102.

16. **Jayasinghe, U.L.B.**, Lakdusinghe, M., Hara, N., Fujimoto, Y. (2012). Phenolic constituents from the fruit juice of *Flacourtia inermis. Natural Product Research, 26,* 278-81.

17. **Jayasinghe, U.L.B.**, Amarasinghe, N.R., Arundathi, B.G.S., Rupasinghe, G.K., Jayathilake, N.H.A.N., Fujimoto, Y. (2012). Antioxidant flavonol glycosides from the leaves of *Elaeocarpus serratus* and the fruits of *Filicium decipiense*, *Natural Product Research, 26,* 717-721.

18. Khaled M. AbuEl-Rub, Hahn, S.-R., Tari, S., **Dissanayake M.A.K.L.** (2012). Effects of $CdCl_2$ heat treatment on the morphological and chemical properties of CdTe/CdS thin films solar cells. *Applied Surface Science, 258(16),* 6142–6147.

19. **Magana-Arachchi, D.N.**, Liyanage, H.M. (2012). Determining the Presence of Cyanotoxins in Anuradhapura Water Reservoirs usingMolecular and Bioassay Methods". *Journal of the National Science Foundation of Sri Lanka; 40(2):*63-73.

20. **Magana-Arachchi, D.N.,** Wanigatunge, R.P. (2012). First report of genus *Chroococcidiopsis* (cyanobacteria) from Sri Lanka using 16S rRNA sequences. *Journal of the National Science Foundation of Sri Lanka.* (JNSF: Script No: 55:2011) (accepted).

21. Makehelwala. M., **Weerasooriya, R.**, Jayaratne, L., **Dissanayake, C.B.** (2012) Thermodynamics of carbofuran adsorption on pyrite, *Journal of Chemical Thermodynamics* 51: 1-.7.

22. **Nanayakkara, A.**, Sakkaff Z. (2012). Fixed distance neighbor classifiers in Brain Computer Interface systems. *Journal of National Science Foundation, Sri Lanka 40.* 195.

23. **Nanayakkara, A.** (2012). Dynamical tunneling-like effects in 1D classical systems. *Journal of Physics A: Mathematical and Theoretical* 45, 444025.

24. **Nanayakkara, A.** (2012). Asymptotic energy expansion for rational power polynomial potentials *Communications in Theoretical Physics 58*, 645.

25. **Nanayakkara, A.**, Mathanaranjan, T. (2012). Equivalent Hermitian Hamiltonians for some non-Hermitian Hamiltonians. *Physical Review A - Atomic, Molecular, and Optical Physics 86,* 022106 .

26. **Nanayakkara, A.** (2012). Asymptotic behavior of eigenenergies of nonpolynomial oscillator potentials v (x) $= x^{2N} + (\lambda x^{m1})/(1 + gx^{m2})$. *Canadian Journal of Physics 90*, 585.

27. **Nanayakkara, A.** Effects of complex time on periodic and non periodic classical trajectories of 1-D Hamiltonian systems. *Canadian Journal of Physics* ~~(in press)~~.

28. Nikagolla, C., Chandrajith, R., **Weerasooriya, R., Dissanayake C.B.** (2012) Adsorption kinetics of chromium(III) removal from aqueous solutions using natural red earth *Environmental Earth Science* (In Press).

29. Perera, M.B.U., Yatigammana, S.K., Athukorala, N.P. (2012). Seasonal Water Quality Variation in Two Different Cascade Systems in the Dry Zone of Sri Lanka. *International Journal of Earth Sciences and Engineering. Vol.05: No 04(01)*, Pp. 877 – 881.

30. Rajapaksha, A. U., **Vithanage, M.**, Weerasooriya, R., Dissanayake, C.B., (2012). Surface complexation of nickel on iron and aluminum oxides: A comparative study with single and dual site clays. *Colloids and Surfaces A: Physicochemical and Engineering Aspects 405(0)*, 79-87.

31. Rajapaksha, A.U., **Vithanage, M.**, Oze, C., Bandara, W.M.A.T., Weerasooriya, R. (2012). Nickel and manganese release in serpentine soil from the Ussangoda Ultramafic Complex, Sri Lanka. *Geoderma 189–190(0)*, 1-9.

32. **Ratnayake, R. R., Seneviratne, G., Kulasooriya, S. A.** (2012). Effect of soil carbohydrates on nutrient availability in natural forests and cultivated lands in Sri Lanka. *Eurasian Soil Science, (Accepted).*

33. **Seneviratne, G.** (2012) Are we wrong in conventional approach of biocontrol? *Current Science 103*, 1387-1388.

34. Sewwandi, B.G.N., Rajapaksha, A.U., Wijesekara S.S.R.M.D.H.R., Jayarathna, D.G.L.M., Mowjood, M.I.M., **Vithanage, M.** (2012). Biosorption behavior of Pb(II) and Cd(II) on coconut husk and saw dust. *Bioremediation Journal, 16(2),* 113-124.

35. **Subasinghe, N.D.**, Jinadasa, P. (2012). Locating of salt and freshwater interface in coastal zones using 2D resistivity imageries. *Applied Mechanics and Materials.* Vols. *212-213,* pp 155-162.

36. **Subasinghe, N.D.** (2012). Electron microscopic studies on phosphate binding processes in the presence of iron. *Advanced Materials Research, Vols. 343-344*, 307-311.

37. **Subasinghe, N. D.** (2012) . Maintaining the Sustainability in Development – A Challenge for Sri Lanka. *Economic Review, People's Bank, Sri Lanka.* (Aug. – Sept.), pp. 35-39.

38. **Vithanage, M.**, Dabrowska, B.B., Mukherjee A.B., Sandhi A., Bhattacharya P., (2012). Arsenic uptake by plants and possible phytoremediation applications- A brief overview. *Environmental Chemistry Letters* (DOI: 10.1007/s10311-011-0349-8).

39. **Vithanage, M.**, Jayarathna, L., Rajapaksha, A.U., Dissanayake, C.B., Bootharaju, M.S., Pradeep, T., (2012). Modeling sorption of fluoride on to iron rich laterite. *Colloids and Surfaces A: Physicochemical and Engineering Aspects 398(0)*, 69-75

40. **Vithanage, M.**, Engesgaard, P., Jensen, K.H., Illangasekare, T.H., Obeysekera,J. (2012). Laboratory investigations of the effects of geologic heterogeneity on groundwater salinization and flush-out times from a tsunami-like event. *Journal of Contaminant Hydrology. 136–137(0),* 10-24.

41. **Weerasooriya, R.**, Indraratne, S.P., Nanayakkara, N., Jayarathne, L., **Dissanayake, C.B.**, Walalawela, N., Bandara A. (2012) Probing pyrite–carbofuran interactions with zeta potential and IR spectroscopic measurements *Colloids and Surfaces A: Physico-Chemical and Engineering Aspects* 396:219-223.

42. Wijeratne, K., Akilavasan, J., Thelakkat, M., **Bandara, J.** (2012). Enhancing Solar Cell Efficiencies through 1-D SnO_2 Nanostructures: comparison of Charge Transport and Carrier Lifetime of SnO_2 particles vs. nanorods. *Electrochimica acta, 72*, 192-198.

14.1 Other publications

1. News paper articles by Dr. M. Vithanage, Mr. S.S.R.M.D.H.R. Wijesekara, Ms. S.S. Mayakaduwa and Ms. R.M.A.U. Rajapaksha.
   - "Avathanva giya rasayanika kamhala", *Vidusara*, 2012/01/04
   - "Kanija ayana bahula Hambanthota boogatha jalaya", *Vidusara,* 2012/02/15
   - "Ninithi thakshanaye nodutu isawwak", *Vidusara*, 2012/03/21
   - "Arctic kalapaye anagathaya", *Vidusara*, 2012/04/25
   - "Paniya jalaye anagathaya-Nirlavaneekaranaya", *Vidusara*, 2012/05/16
   - "Apa leda karawana apema kasala", *Lankadeepa,* 2012/06/05
   - "Ussangoda wata gethunu mathawada saha ehi vidyathmaka pasubima", *Vidusara,* 2012/06/05
   - "Jala sampatha raka genimata pariganakaye sahaya", *Vidusara*, 2012/07/11
   - "Kasala bimen gala yana apa jalaya", *Vidusara,* 2012/08/15
   - "Kantharakaranaya", *Vidusara*, 2012/10/03
   - "Indian sagara pathla pupura yai", *Vidusara*, 2012/10/31
     "Apa jalaya piripahadu kirima sandaha kshudra ninithi loya saha loha oxide bavithaya", *Vidusara,*2012/11/14.

2. "Human tricks won't solve monkey problem" by Wasantha Ramanayake, *Sunday Times*, June 10, 2012.
3. "Now a human-monkey conflict!" by Ravi Ladduahetty, *Sunday Island*, 1 June , 2012.
   (based on interviews and documents submitted by W. Dittus)

4. Tilakarathna,T.C.P.K. (2012).*"Noselena Potha".* National Reading Month commemorative volume National Library and documentation services board, October 2012,30-33.

5. Tilakarathna, T.C.P.K. (2012) .*"Vidyuthmadya Hamuwe Noselena Potha". Desathiya*, October 2012, 38-39.

6. Tilakarathna, T.C.P.K. (2012) . "How to Improve Reading Habits in Children". Kegalle Balika *Pankaja News Magazine*, October 2012, 3-7.

7. Tilakaratne, C.T.K. (2012). "Nano Kurumittage Yoda Shakyatha", *Vidusara* Newspaper, 2nd May 2012.

8. Tilakaratne, C.T.K. and Thakshalee H. (2012) "Science imerging from our daily life", *Vijaya* Newspaper, 21st August, 2012.

14.2 Chapters in Books

1. Benjamin, S.P., Nanayakkara, R.P. & Dayananda, S.K. (2012). The Taxonomy and Conservation Status of the Spiders (Arachnida: Araneae) in Sri Lanka. In: The National Red List of Sri Lanka; Conservation Status of the Fauna and Flora. Weerakoon, D.K. & S. Wijesundara Eds., Ministry of Environment, Colombo, Sri Lanka. 42-57.

2. Liyanage, R., Jayawardana , B. C., Kodithuwakku, S.P. "Potential Novel Therapeutics: Some Biological Aspects of Marine-derived Bioactive Peptides"In Marine proteins and peptides. (In press).

3. Magana-Arachchi, D. (2012). "Pattern of circulating *Mycobacterium tuberculosis* strains in Sri Lanka"; In. Pere-Joan Cardona (ed). Understanding Tuberculosis - Global Experiences and Innovative Approaches to the Diagnosis. In Tech publishers, ISBN 978-953-307-938-7. Chapter 24, 511-526

4. Magana-Arachchi , D. (2012). "Epidemiology of MDR-TB"; In. BassamMahboub (ed). Tuberculosis. In Tech publishers, ISBN 980-953-307-872-9.

5. Wijeratne, K., Akilavasan, J., Bandara J. Efficiency Enhancement of Dye Sensitized Solar Cell by Incorporating Li Ion In to ZnO Nanosturcures, Fuelling the Future: Advances in Science and Technologies for Energy Generation, Transmission and Storage, 173-177, BrownWalker Press, 2012, ISBN-13: 978-1-61233-558-2.

14.3 Reviewer

Prof. M.A.K.L. Dissanayake
(i). Seven research publications were reviwed for the Journal of Power Sources.
(ii). One research publication was reviewed for the Journal of Materials Chemistry and Physics.
(iii).Two reseach publications were reviewed for the Journal of the National Science Foundation of Sri Lanka (JNSF)
(iv). One research publication was reviewed for the Ceylon Journal of Science Physical Sciences)
(v). One Research Grant Proposals were reviwed for the National Research Council
(vi). Three research Grant Proposals were reviwed for the National Science Foundation.
(vii).One Reserach publication was revived for the journal of Open University of Sri Lanka
(ix). One extended abstract was revived for the Annual Acdemic Sessions of the Open University of Sri Lanka
(x). One research grant proposal was revived for the Naional Science Foundation(
(xi.) One research article was reveived in ChemSusChem (2010 ISI Impact Factor: 6.325) (Wiley-VCH Verlag GmbH & Co. KGaA)
(xii). One Research article was revived in Polymer Engineering & Science

Dr. W. Dittus
Editorial Board and Reviewer for Journal of Primatology.
Reviewer for National Science Foundation (Sri Lanka)

Dr. M.C.M. Iqbal
Ceylon Journal of Science, Journal of the National Science Foundation of Sri Lanka, ASDA journal – Agriculture Symposium of the Department of Agriculture

Prof. U.L.B. Jayasinghe
Reviewer, PGIA, University of Peradeniya, Annual Congress - 2012
Reviewer, *Natural Products Research* [Manuscript ID: GNPL-2012-1061]
Reviewer, NSF Progress Review Seminar -2012

Prof. N.S. Kumar
Evaluator of Final Report on research grant RG/2011/25/M "Antifungal Activity of tea catechins against fungal species" awarded by the University of Peradeniya.

Reviewer. Higher Education for the Twenty First Century (HETC) – Quality and Innovation Grant - (QIG) Window 3. Postgraduate Research Programs. Site Visits

Reviewer. (HETC) – QIG Window 4. Research Dissemination and Commercialization Projects, Evaluation of Proposals and Site Visits.

Member, Technical Advisory Committee on Good Laboratory Practices, Sri Lanka Accreditation Board (SLAB)

Dr. D.N. Magana-Arachchi
Research Article ; BMC Infectious Diseases
Research Grant proposal – National Research Council (NRC) 2012
Review of Scientific Paper – Annual Symposium of the Department of Agriculture –ASDA 2012
Two PhD Project Proposals – Faculty of Graduate Studies, University of Sri Jayewardenepura

Dr. K.G.N. Nanayakkara
Reviewer to following journals :
Bioresource technology
Marine Technology Society (MTS) Journal

Dr. R.R. Ratnayake
Reviewer for Agriculture Ecosystem and Environment (Elsevier, Impact factor 3.13)
Reviewer for Plant & Soil (Springer, 2.77)
Reviewer for Agro forestry Journal

Dr. R. Liyanage
British Journal of Nutrition
PGIA, University of Peradeniya
ASDA Journal-Agriculture Symposium of the Department of Agriculture

Dr. M. Vithanage
Clean: Soil, Air, Water (Impact Factor – 2.177)
Journal of Chemical Engineering (Impact Factor – 3.461)
Environmental Chemistry Letters (Impact Factor – 1.881)
Bioremediation Journal (0.784)
Environmental Science and Pollution Research (2.651)
Journal of Industrial and Engineering Chemistry (1.977)
Journal of Hazardous Materials (Impact Factor – 4.173)
Journal of Environmental Engineering Science
Ceylon Journal of Science

14.4 Examiner

Prof. U.L.B. Jayasinghe, University of Peradeniya, (2012). M.Phil. thesis title: Isolation of microbial biofilms as agents of cellulosic Bio- degradation of invasive weeds for bio-fuel production in Sri Lanka.

Prof. U.L.B. Jayasinghe, University of Peradeniya, (2012). M.Phil. thesis title: Tea Catechins: Antibacterial activity against Methicillin-Ressistant *Staphylococcus aureus* (MRSA) and enhancement of sensitivity of MRSA to oxacillin

Prof. U.L.B. Jayasinghe, University College Dublin, Ireland, (2012). Ph.D. thesis title: Investigation on the biological activity of some medicinal plants.

Prof. U.L.B. Jayasinghe, University of Peradeniya, (2012). M.Sc. Project Report (PGIS/PL/M.Sc./PLS/03/71).

Dr. Vithanage participated as an examiner at the Department of Biological Environment, Kangwon National University, Korea for evaluation of a PhD.

14.5 Conference Abstracts/Papers

1. Abeygunawardhana,P.W., Weerakkody, C., **Nanayakkara, N.** (2012). Optimization of electrode material for electrochemical denitrification in chloride free environment, Symposium on "The Potential Health and Environmental impacts of exposure to hazardous natural and man-made chemicals and their proper management" , Colombo City Hotel, Colombo, Sri Lanka, 22-23 November 2012.

2. Akilavasan, J., Wijerathne, W.M.K.T., **Bandara, J.** Reduction of charge carrier recombination and enhancing the overall solar cell performance by coating of a thin MgO layer on titania nanotubes International Conference on Advanced Materials, Science and Engineering (ICAMSE) in Colombo, Sri Lanka on July 2-3, 2012.

3. Akilavasan, J., Wijeratne, K., Gannoruwa, A., Alamoud, A., **Bandara, J.** Significance of $TiCl_4$ post-treatment on the performance of hydrothermally synthesized Titania Nanotubes Based Dye Sensitized Solar Cells, The 2nd Saudi International Nanotechnology Conference in Riyadh, Saudi Arabia on November 11-13, 2012.

4. Bandara, D.M.D.P.K., **Magana-Arachchi, D.N.** (2012).. Detection of uterine sensitization associated gene-1 or WISE Gene in *Mycobacterium tuberculosis.Proceedings of the Sri Lanka Association for the Advancement of Science*, 68th Annual Session, 10-12th December 2012. p4.

5. Buddhika U.V.A., Athauda A.R.W.P.K., **Kulasooriya S.A., Seneviratne G.**, Abayasekera C.L. (2012) Developed microbial biofilms for rehabilitating deteriorated soil/plant system in conventional maize. *In.* Proceedings of Sri Lanka – India Conference on Agro Biotechnology for Sustainable Development. 12-13 March, B.M.I.C.H., Colombo, Sri Lanka. P. 62.

6. Buddhika U.V.A., **Kulasooriya S.A., Seneviratne G.**, Abayasekera C.L. (2012) Potential of biofilmed microbial communities as biofertilizers for maize (Zea mays L.). *In.* Proceedings of Sri Lanka – India Conference on Agro Biotechnology for Sustainable Development. 12-13 March, B.M.I.C.H., Colombo, Sri Lanka. P. 3.

7. Buddhika, U.V.A., **Seneviratne, G.**, Abayasekera, C.L. (2012) Nitrogen fixing bacteria in microbial biofilms can conquer nutrient deficiencies under low fertilizer rates in maize cultivation. 16th Australian Nitrogen Fixation Conference, Q station, Sydney, Australia. 24-27 June 2012.

8. Buddhika, U.V.A., **Seneviratne, G.**, and Abayasekara, C.L. (2012). Biofilmed biofertilizers for maize (*Zea mays* L.): effect of plant growth under reduced doses of chemical fertilizers. In: B. Nimalathasan, A. Ramanan and K. Thabotharan (Eds), Jaffna University International Research Conference-2012, Jaffna, P. 8.

9. Chandika, S.D.P.M.P., Jayawardana, B.C., Vidanaarachchi, J.K., **Liyanage R.** (2012) Antioxidant effect of onion on lipid oxidation and sensory qualit,ies of cooked pork sausages, Proceedings of 68th Annual Sessions of Sri Lanka Association for the Advancement of Science, December.

10. Chathuranga, P.K.D., Iqbal, S.S. (2012). Sustainable technology for clean water. In Planet Under Pressure 26-29 March, London – UK.

11. Chathuranga P.K.D., **Iqbal M.C.M.**, Priyantha N., Iqbal S.S. (2012). Removal of aqueous chromium(III) by non-living *Cabomba caroliniana.* In 5th International Congress of Environmental Research 22-24 November, Kuala Terengganu, Malaysia.

12. Chathuranga P.K.D., Iqbal S.S., **Iqbal M.C.M.**, Priyantha N. (2012). Biosorption of chromium(VI) from aqueous systems by non-living *Cabomba spp.* In 18th Annual Scientific Sessions of Sri Lanka Association for Fisheries and Aquatic Resources 17-18 May, 2012 Colombo.

13. De silva, N., Wijesekara, S.S.R.M.D.H.R., Basnayake, B.F.A., **Vithanage, M.** Proceedings of the 28th Annual Sessions, Geological Society of Sri Lanka. 24th February, 2012.

14. Dharmapriya, P. L., Malaviarachchi, S.P.K., **Subasinghe N.D., Dissanayake C.B.** (2012). Textural evidence for UHT metamorphism in Sri Lankan granulites: Preliminary Results. *28th Annual Technical Sessions of the Geol. Soc. Sri Lanka*, Colombo, 24 Feb. 2012.

15. Herath, H. M. L. I., Gunarathne, H. K.S.N.S., **Seneviratne, G., Vithanage, M.** (2012). Fungal-Bacterial Biofilms Show High Cr (VI) Tolerance than Bacterial Biofilms or their Mono Cultures as Potential Bioremediater. 6th American Society for Microbiology Conference on Biofilm, Miami, Florida, USA. 29 September - 4 October 2012.

16. Herath, H. M. L. I., Senanayeke, D. M. N., **Seneviratne, G.,** Bandara, D. C. (2012). Significance of Biochemical Expressions of Fungal- Bacterial Biofilms on Plant Growth Enhancement. 6th American Society for Microbiology Conference on Bio film, Miami, Florida, USA. 29 September - 4 October 2012.

17. Iddamalgoda, I.S.T., Jayawardana, B.C., Vidanarachchi J.K., **Liyanage R.** (2012) Antioxidant and antimicrobial activity of drumstick (*Moringa oleifera*) leaves in herbal sausages, In proceedings of the twenty second annual research session, Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka.

18. **Jayasinghe, U.L.B.** (2012). Invited Lecture: "Search for environmental friendly bioactive Natural Products". *International Symposium on Drug Discovery, Sabaragamuwa University of Sri Lanka, Belihuloya*, Sri Lanka, 5th Jan.

19. **Jayasinghe, U.L.B.** (2012). Invited Lecture. " Search for environmental friendly bioactive compounds", *13th International Symposium on Natural Product Chemistry*, 22nd-25th Sept. Karachi, Pakistan, p.37

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Institute of Fundamental Studies
Hantana Road
Kandy
Sri Lanka

Web Site : www.ifs.ac.lk
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Printed by:
Sanduni Offset Printers (Pvt.) Ltd., Peradeniya. 081-2387777