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CHEMISTRY
IN SRI LANKA

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Institute of Chemistry Ceylon – Council 2017/2018

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Absentees: Prof (Mrs.). J Liyanage, Ms. D. Seneviratne (Hony. Secretary).

Chemistry in Sri Lanka

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The Tri-Annual Publication of the Institute of Chemistry Ceylon

Founded in 1971, Incorporated by Act of Parliament No. 15 of 1972

Successor to the Chemical Society of Ceylon, founded on 25th January 1941

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Theme for the year -

Chemists' contribution towards National Policy Development

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Outline of our Institute

The Institute of Chemistry Ceylon is a professional body and a learned society founded in 1971 and incorporated by act of Parliament No. 15 of 1972. It is the successor to the Chemical Society of Ceylon which was founded in 1941. Over 50 years of existence in Sri Lanka makes it the oldest scientific body in the country.

The Institute has been established for the general advancement of the science and practice of Chemistry and for the enhancement of the status of the profession of Chemistry in Sri Lanka. The Institute represents all branches of the profession and its membership is accepted by the government of Sri Lanka (by establishment circular 234 of 9-3-77) for purposes of recruitment and promotion of chemists.

Corporate Membership
Full membership is referred to as corporate membership and consists of two grades: **Fellow (F.I.Chem.C.)** and **Member (M.I.Chem.C.)**

Application for non-corporate membership is entertained for four grades: **Associate (former Graduate) (A.I.Chem.C.), Licenciate (L.I.Chem.C.), Technician (Tech.I.Chem.C.) and Affiliate Member.**

Revision of Membership Regulation
All Special Degree Chemists can now apply directly to obtain **Associate (Graduate) Membership.** Three year B. Sc. Graduates (with an acceptable standard of Chemistry) can
(i) directly become **Licentiate**
(ii) obtain corporate membership in a lesser number of years.

Tech.I.Chem.C.
Those who have passed the DLTC examination or LTCC examination or have obtained equivalent qualification and are engaged in the practice of Chemistry (or chemical sciences) acceptable to the Council are entitled to the designation Tech.I.Chem.C.

Members/Fellows are entitled to the designation of **Chartered Chemist (C.Chem.)** on establishment of a high level of competence and professionalism in the practice of chemistry and showing their commitment to maintain their expertise.

All corporate members (Members / Fellows) are entitled to vote and become Council/ Committee members whether Chartered Chemists or not.

Membership Applications
Any application for admission to the appropriate class of membership or for transfer should be made on the prescribed form available from the Institute Office.

Current Subscription Rates
Fees should be payed on 1st of July every year and will be in respect of the year commencing from 1st July to 30th June

Fellow	Rs. 1500
Member	Rs. 1500
Associate	Rs. 1200
Licenciate	Rs. 1000
Technician	Rs. 500
Affiliate	Rs. 1000
Membership for Life	Rs. 15000

Entrance Fee

All the grades	Rs. 1000
Processing Fees*	Rs. 500
Processing Fee for Chartered Chemist designation	Rs. 1000
Institutional Members	Rs. 2500

*per application for admission/transfer to any grade

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CHEMISTRY IN SRI LANKA

Chemistry in Sri Lanka is a tri-annual publication of the Institute of Chemistry Ceylon and is published in January, May and September of each year. It is circulated among the members of the Institute of Chemistry and students of the Graduateship/DLTC course and libraries. The publication has a wide circulation and more than 1000 copies are published. Award winning lectures, abstracts of communications to be presented at the annual sessions, review papers, activities of the institute, membership news are some of the items included in the magazine.

The editor invites from the membership the following items for publication in the next issue of the Chemistry in Sri Lanka which is due to be released in January 2018.

- *Personal news of the members*
- *Brief articles of topical interests*
- *Forthcoming conferences, seminars and workshops*
- *Latest text books and monographs of interest to chemists*

All publications will be subjected to approval of the 'Editorial and Publicity Committee' and the Council of the Institute of Chemistry Ceylon.

Further, prospective career opportunities for chemists, could be advertised in Chemistry in Sri Lanka at a nominal payment. The editor welcomes from the members suggestions for improvement of the publication.

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Cover Page

The first National Chemistry Olympiad competition was conducted on 15th and 16th May 2017 at the Institute of Chemistry Ceylon.

See pages 34-35 for details and photographs.

Guest Editorial

Chemists' role towards National Policy Development

Professor Sudantha Liyanage

Dean, Faculty of Applied Sciences, University of Sri Jayewardenepura

The Institute of Chemistry Ceylon, the successor to the Chemical Society of Ceylon founded in 1941 has travelled a remarkable journey in the advancement of chemical sciences and practice of chemistry since its inception 46 years ago. It has grown and expanded into one of the leading institutes producing chemists and also diplomates who are holding diligent positions in academia, state and private sector institutes and in the industry. Further, a growing number of graduates are embarking on postgraduate degrees in recognized universities world over marking the presence of the Institute of Chemistry Ceylon internationally as well. Further, yeomen service rendered by the Institute of Chemistry Ceylon to the health and wealth of the society and to the nation's economic development through training, dissemination of information, encouraging good standards of practice and popularization of chemistry is commendable.

Chemistry is involved in both the natural world and the man-made world. Everything we interact with on a daily basis involves chemistry. Thus, it is no surprise that chemistry is considered as "the central science" in the context of its relationships within the group of "natural sciences" that includes physics and biology. Chemistry provides the basis for understanding the atomic and molecular aspects of these disciplines and, through its interfaces with a range of pure and applied sciences, underpins the dramatic advances seen in recent decades in such diverse fields as medicine, genetics, biotechnology, geology, astronomy, materials science, energy and many other areas of study.

Due to the nation's increased development activities and to keep up with the global paradigm shifts towards "green economy", revisiting the weaknesses, limitations and lapses in past policies and to set up new policies for national economic development and in general for the health and well being of its people is timely. Full potential of developed policies can only be harnessed by implementation and devising strategies to find out the policies' performance to the society and to the nation.

Some important areas that need attention with this respect are as follows.

- Science and Technology education and training
- Financing national research and development
- Exploitation of untapped natural resources
- Value addition of natural resources
- Environmental protection
- Regulation of medicines

The Institute of Chemistry Ceylon, the professional body for chemists and the oldest such body in any branch of the basic sciences in Sri Lanka has an enormous role to play towards national policy development. Thus, with this in mind the theme for the year 2017-2018 of the Institute of Chemistry Ceylon was set up as "Chemists' Role towards National Policy Development".

"Days ahead will be better if we make the right choices today to meet the challenges that face us tomorrow".

Message from the President

Dr. Poshitha Premarathne, *C.Chem., F.I.Chem.C., C.Chem. MRSC*
President, Institute of Chemistry Ceylon

I would like to begin by quoting from Emeritus Professor Peter Fellgett of Cambridge University, who maintains that "universities should not stick only to the task of teaching". New knowledge needs to be gathered and constantly improved upon and updated, and entered into the teaching curriculum. This can be achieved if these institutes of higher education carry out both fundamental and advanced research and innovation, and through networking with other eminent teaching and research establishments. This is more so poignant in the case of a core science like chemistry.

When it comes to institutional research, one must consider that innovation plays a critical role to commercial success. However, the emerging trend today for commercial success appears to be a market driven innovations, and research and development. This is borne out by market research findings and share price statistics of, for example of big pharmaceutical and nutraceutical companies. The demand for novel chemical products is supported by chemical informatics and the development of concomitant databases, where researchers can evaluate and find out which particular features or part of a molecule fit in closest to the structure-function format, or which ligands interact best with a given receptor. Once novel products are developed, companies will be able to work on new formulations, as has been done in the past with success.

For us to carry out meaningful research and development there should be adequate funding and attractive remuneration and societal appreciation. At present 0.13% of GDP in research funding, if increased to over 1% might help in producing our research and development personnel, which at present stands at 25% of the world average.

Our own situation at the College of Chemical Sciences of the Institute of Chemistry Ceylon is the inadequate space for both teaching and more so for research despite having an eminent teaching and research staff. In lieu of this, a major ambitious programme was launched sometime back. Construction of buildings on one acre land that is being transferred to the Institute by the Urban Development Authority will house modern lecture halls, laboratories, library, gymnasium, recreation facilities *etc.* With the new modern facilities available, BSc Special Degree programme will be commenced in addition to continuing with the existing Graduateship in Chemistry programme.

On an invitation by the Ministry of Science, Technology and Research, the Institute has been requested to prepare and forward a proposal intended for national development strategies. In this proposal chemists' role in fields such as food, agriculture, health and pharmaceutical industry, environment and energy are highlighted. Further discussions are in progress at present with the Ministry officials.

There has been a long felt need for an innovation center to foster an innovation culture in the country. In any developing economy there are numerous innovation centers because the birth and developments of independent free flowing thoughts happen there. Inventions and innovations of new products and services, technology skill development and finding industrial solutions all happen at these innovation centers. The Institute of Chemistry Ceylon too has a vision of establishing such a center. We at our Institute are collaborating with two State Ministries namely the Ministry of Megapolis and Western Development, and the Ministry of Science, Technology and Research in this regard.

At least the two State Ministries named above feel earnestly that the Institute of Chemistry Ceylon can and should play a vital role to design an economic development strategy to enhance economic growth, through chemical sciences, and thereby improve the country's appalling GDP index.

Forty Sixth Annual Sessions and Seventy Sixth Anniversary Celebrations 2017

Presidential Address

Mr. M R M Haniffa, *F.I.ChemC, C.Chem.,*
Immediate Past President, Institute of Chemistry Ceylon
Senior Lecturer in Chemistry, the Open University of Sri Lanka

I consider it an honour and privilege to deliver the Presidential Address at the Inauguration Ceremony of the 46th Annual Sessions of the Institute of Chemistry Ceylon (ICHEMC).

At the outset, may I mention that I wish to dedicate my address this morning to the late Emeritus Professor J.N. Oleap Fernando who passed away suddenly on 2nd March 2015 leaving a huge vacuum in the academic and the administrative circles at the ICHEMC. It was he who was responsible for recruiting me as a temporary demonstrator at the Open University of Sri Lanka in 1990, and it was he who nominated me to the position of the Vice President of the ICHEMC, a forerunner to the post of President. Unfortunately, he did not live to see either me or Mr Dayananda, the immediate past president, taking up the Presidency of the ICHEMC. We miss him at a time when his forthright advice and opinion are needed most. It may be significant to mention that the two scholarships offered in memory of the late Professor, namely, the J.N. Oleap Fernando memorial scholarships, will be presented this morning for the first time. I must take this opportunity to thank all those who contributed to the fund established in this regard enabling us to carry forward one of the long term visions of the late Professor, that of recognizing and rewarding student achievements. Unfortunately, Madam Mandrupa Fernando (wife of the late Professor) who is a special invitee this morning is unable to be present as she has undergone a cataract operation. I am sure she would have been the happiest person to witness one of the dreams of her late husband's come true.

I browsed through the Council themes over the past two decades or more. Many themes such as those mentioned below have been put forward, all of which in my mind including the present theme revolves round the subject of CHEMISTRY.

- Chemistry is the Central science,
- Chemists for a better living,
- Chemistry for value addition,
- Chemistry, the key to quality in industry,
- Chemistry in the service of the people,
- Chemists and the environment,
- Chemistry for the masses,
- Chemistry for healthy living
- Chemical Sciences – a multi disciplinary approach for the new millennium,
- Sustainable technologies for the developing countries- the Role of Chemists

In keeping with tradition, the subject of my address was expected to center round the Council theme for 2016/2017; that is **"Role of Chemists for a better tomorrow**".

Since there is a full day of deliberations under this theme tomorrow when we hold the theme seminar, I have decided to change the title of my address to "**Chemists: from the past to the future; recognition of chartered chemists"**, which would enable me to share some of my own thoughts with you this morning.

One needs to look back at some of the great scientists of the past – inc. Chemists, Physicists – for inspiration. They are all very familiar faces who have carried out ground breaking research work under extremely difficult circumstances. [The following are some of the highlights that were featured in the power point presentation that followed the Presidential Address as part of the reference to the Past and the Future]

- Few famous names of scientists were highlighted in order to inspire the current generation; the question is "where do we stand in comparison"?
  Albert Einstein, Arrhenius, Thomas Edison, Debye, Nernst, Avogadro, Rutherford, Boyle and Micheal Faraday, Marie Curie Sir Alexander Fleming
- *Quotes from Marie Curie*
  "Have no fear of perfection; you'll never reach it".
  "Be less curious about people and more curious about ideas".

- *Quote from Professor Abdul Kalaam*
  "You cannot change your future but you can change your habits, and surely your habits will change your future"

Recognition for Chartered Chemists

When it comes to gaining **recognition for Chartered Chemists**, there is a great need for those involved in chemistry related work to take up this challenge, create a positive impact in the minds of the public, impress upon them the important role played by chemists in their day to day activities; in other words, the practicing chemists have to **change their habits**, get involved in public debate (for eg; CKDu, impact of heavy metals on the health of the nation *etc*.), write to the newspapers in order to make their presence felt. One cannot expect miracles to take place overnight for the Chartered Chemists to be given official recognition; recognition would take time and collective effort of all of us; it cannot be achieved by a handful of us.

Chemistry as a subject and Chemists as a profession are closely linked. The ICHEMC has a major role in taking this message forward to gain recognition for chemists. It is an accepted fact that Chemistry is the central science, that Chemistry is everywhere; it is part of any sphere of life, be it agriculture, industry or even the household. However, the public perception of this subject (the image as it were) is not in keeping with the contribution made by those practicing the profession where chemistry plays a major role.

Chemistry is associated with many areas including education, pharmaceuticals, forensics, environment, polymer industry, nanotechnology, biochemistry, toxicology, medicine, fuels, nuclear chemistry, material science, petrochemical industry, mineral science, and many more; the associated designation of personnel could be as diverse such as Analytical Chemists, Research Chemists, Developmental and Production Chemists. Environmental Chemists, Metallurgical Chemists, Food Chemists, Processing Chemists *etc*.

Most of us take medicines, whether it is paracetamol for a headache, a statin to lower cholesterol or something to treat a specific condition we have. However, just how do these treatments come about, how do we decide what to treat and how, what is it got to do with chemistry? Chemists have played a dominant role in this regard in terms of the successful design of molecules which interact with specific biological targets in overcoming specific health problems. Chemists played a central role in developing a revolutionary new medicine for the treatment of AIDS/HIV, thereby saving lives and improving the quality of life of those patients.

There is no question that chemical usage in any form and in any endeavor need to be minimized. In the Sri Lankan context, this matter has taken on a new dimension in the light of the prevailing situation in the NCP related to CKDu. The debate goes on to determine the causes for this extremely devastating disease that is causing so much pain and agony. I do not think it is necessary to discuss the status of this problem at present but, rather, wish to highlight the fact that such issues need a collective effort of the Scientist in general and Chemists in particular. A different approach involving dietary controls is a topic at the theme seminar scheduled for tomorrow and I am sure that would be of interest to all of us here.

The Institute of Chemistry Ceylon, as a professional body of Chemists, was established for the general advancement of Science and for the practice of Chemistry in particular and for the enhancement of the status of the profession of Chemists in Sri Lanka. The Institute has made great strides in creating awareness of the importance of Chemistry in daily life and in the development of industry. In this context, there is a great need to take this message forward in order to attract the attention of the general public, a key step in gaining recognition for the Chartered Chemists and hence, a challenge for the Members of the ICHEMC and those in the chemical industries and research institutes who are practicing chemists. It is hoped that creation of an **Assurance Board of Chartered Chemists** would lead to empowerment of the chemists in national development.

Chief Guest's Address

Creative Hybrid Chemistry for a Better Tomorrow

Mr S K Cyril Suduwella

Advisor and Coordinator to the Hon. Minister of Science, Technology & Research

It gives me great pleasure to join you this morning, at the 46th Annual Sessions of the Institute of Chemistry Ceylon.

I would like to express my thanks and gratitude to the Council of the Institute of Chemistry Ceylon, and all the organizers, supporters and sponsors involved in this impressive Inauguration Ceremony.

The theme of the Annual Sessions is "Role of Chemists for a Better Tomorrow". Given that there are so many chemists gathered here this morning, I would like to start by noting all of your important contributions to the society. The chemical industry is crucial to world's prosperity. I can think of a few others so intrinsically linked to science and to the prosperity of mankind. Economically the outputs of Applied Chemistry and Chemical Engineering are enormous for Sri Lanka. A few other areas of science too contribute directly to our industrial successes. Regardless of whether it is in medicine, energy, computing, transport or your sector's involvement lead to products and services that make people's lives better, healthier and safer.

Unfortunately, like any industry, yours too faces challenges. One is securing a workforce with the necessary skills. World needs trained chemists and technicians to work in food processing, food packaging, recycling, waste management, petroleum and petrochemicals, nanotechnology, mining services, healthcare and construction *etc*. Skill improvements in countries such as China, India, South Korea and Singapore in our region are at a faster rate than Sri Lanka and are thereby gaining a competitive edge. While we face significant competition for these skills in our region, other nations like the United States are also putting in place measures to try and bolster capacity.

President Obama says, and I quote "*With the pace of technological innovation today, we can not afford to stand still for a year or two years or three years. We have got to seize every opportunity we have to stay ahead. And we can not let other countries win the race for ideas and technology of the future*."

If the United States, the world's biggest contributor to Science cannot afford to stand still, you can bet that Sri Lanka needs to be doing a lot more.

Before I discuss the challenges of tomorrow for our scientists and engineers, let me give you an overview of present scenario.

STEM (Science, Technology, Engineering and Mathematic) contributes to a better society, economy and nation. We know that science-related study prepares a student for a lifetime of critical thinking, and motivate them to find evidence and develop understanding of our natural world and our constructed world. Further, I think it is important to note that STEM skills are not only needed in STEM occupations, but in other economic sectors as well.

For years, Sri Lanka has been recognized as one of the world's leading financial centers for tea, rubber, coconut, spices, gems, ivory and many other natural products. However, we no longer the main producer of these.

According to the latest Global Innovation Index, organized by Cornell University, INSEAD and the UN's World Intellectual Property Organization, Sri Lanka is ranked outside the top 50 of the most innovative countries in the world. More than 140 economies were involved in this survey. Sri Lankan scientists have also earned a place in innovations, and young scientists who demonstrate a commitment to both excellence in scientific research and co-operation with other economies are being recognized. I am proud of world-class achievers from our motherland. However, more than the individual honours, I take heart in the larger message: that we, here in Sri Lanka, have the talent, and the opportunity, to succeed at the very highest level of innovation and research.

Fundamental and Applied Research, and Innovations can diversify our economy, providing wider employment opportunities in Research and Development. Further, that can enhance the competitiveness and growth of related industries.

In industry, the term "research" is frequently used to describe innovation with existing technology, which academic scientists would normally describe as development. This different use of the word "research" can lead to many misunderstandings. I use the word in

the sense understood by academic scientists.

I do not like the terms basic and applied science: after all who can say in advance what is applicable? However, these terms can be useful provided they are defined in terms of motivation; Basic science - motivated by curiosity, Applied science - designed to answer specific questions.

Funding of basic science is important for the society as a whole. However, that is not in the interest of any individual investor. Those who make fundamental discoveries generally do not reap the benefits.

Investment in basic science is not of interest for any individual enterprise, but it is nevertheless very important for the society as a whole, i.e. basic science is what economists call a "public good". Public goods are items such as lighthouses and defense, which are expensive to produce, but once produced are essentially automatically available to all, even if they are unwilling to pay. Such items are generally likely to be supported collectively by governments.

Governments should therefore support basic science, on the basis of the benefits of the directly acquired knowledge. Whenever profit is easily foreseeable, industry will invest and governments can generally stay away, although they can play some role e.g. by encouraging contacts and collaboration between industry and universities.

The world economy has had a rough start in 2017, and that will continue to be characterized by a new abnormal behavior of growth, economic policies, inflation and financial markets. Potential growth in developed markets and emerging markets has fallen. That potential has fallen due to many reasons. Meanwhile, technological innovations have not translated yet into higher productivity growth at the aggregate level.

A global competition for research in technology is underway. Developed Countries are using a variety of strategies to recruit talent, including persuading expatriates and experts from abroad with superior financial support, offering top working conditions and research facilities, expanding higher educational opportunities to attract internal and external students, and recruiting multinational companies to open research and development facilities in order to meet today's challenges in the field of basic science and technologies.

Asian students are strong in science, technology, engineering and mathematics. We need to encourage more of them to pursue Innovation and Technology careers. Further, we need dedicated leadership and stronger policy coordination among the various stakeholders in government, industry, academia and researchers.

We have been concerned with basic science and its support by government funds in a modern society. Although there is some support by private institutions established for that purpose and also some industrial investment in generally product-oriented basic research, the greatest amount of support by far comes from public funds. One of the ways that the public is repaid for their support is through the technology that fundamental research generates. I suspect that the economic return from technology alone more than compensates for the monies expended for the entire basic research effort. I have no estimate, however, of whether my suspicion is true or not. It should be noted that the public gains much more than the economic value of technology. It gains culture, comfort, convenience, security, recreation, health and the extension of life, if research findings are transformed into useful technologies or products.

I know this Annual Sessions will inspire a multitude of ideas, thanks to all of you who are here. Some of those ideas of researchers may well become start-ups. A few may even become game-changing businesses. When that good day arrives, researchers will have achieved their goals.

I wish you all a very successful event.

Guest of Honour's Address

Dr. M.M.J.P. Gawarammana
Chairman, Tea Research Board, Talawakelle

First and foremost, I would like to extend my gratitude for inviting me as the Guest of Honour for the 46th Annual Sessions of the Institute of Chemistry Ceylon under the theme "Role of Chemists for a Better Tomorrow".

While going through the mandate of this Institute, I understood that maintenance and enhancement of the profession of chemistry in Sri Lanka is your responsibility. For that, the steps you have taken in the history to promote and advance the science of chemistry and its applications in Sri Lanka was very important. I am sure that today's event too will help to enhance your objective.

The Institute of Chemistry Ceylon is a nationally, and internationally recognized Institute that produces quality chemistry graduates equally recognized by local and foreign universities by providing opportunities for talented students who could not enter universities. They are contributing significantly to national economy by providing their services for public and private sector, reputed companies, universities and organizations.

Chemistry plays a major role in all the fields in the world. While thinking in deep, the problems in various fields, such as medicine, agriculture, food and environment are solved by introducing chemicals by chemists. Therefore, no doubt that chemistry is the most important subject to find practical and sustainable solutions for problems in the various fields of science today.

As Chairman of the Tea Research Board of Sri Lanka, it is my duty to explore in brief the knowledge of Chemistry utilized in the field of tea research. Firstly, I am proud to say that the Director and the Additional Director of my Institute are chemists and also Members of the Institute of Chemistry Ceylon. Apart from them, there are scientists working in Bio-Chemistry division of the Institute, who are also Chemists.

there are nine research divisions and one division for Advisory and Extension work in the Head Office of the Tea Research Institute (TRI). Further, we have two Regional Centres in Ratnapura and Kandy including four Regional Advisory and Extension Centres in different agro-ecological regions. Out of nine research divisions in the TRI, except Agriculture Economics Division, all the other divisions have to perform their research based on principles of chemistry.

TRI and other crop research institutions benefitted by the graduate chemists produced by the Institute of Chemistry Ceylon. Their careers, such as from Technical Officer to Senior Research Officer, were developed because of the Institute of Chemistry Ceylon.

We do trials in Agronomy division, value addition research in Bio-chemistry division, soil and fertilizer research in Soil and Plant Nutrition division and introducing safe chemicals for pests and diseases by Entomology/Nematology and Plant Pathology divisions are a few examples of utilizing chemistry in tea research.

Accordingly, it is obvious that chemistry plays a vital role in the field of tea as in all the other sectors. TRI doors are open for you to do collaborative research activities as a policy of the present government.

Finally, I wish the Institute of Chemistry Ceylon to do further great services for the nation.

46TH ANNUAL SESSIONS OF THE INSTITUTE OF CHEMISTRY CEYLON

Mr. M R M Haniffa delivering the Presidential Address

Mr S K Cyril Suduwella, Chief Guest delivering his address

Dr. M.M.J.P. Gawarammana, Guest of Honour delivering his address

Dr. (Ms.) C Padumadasa receives the Professor M U S Sultanbawa Award

Ms. C L Kehelpannala receives the Kandiah Memorial Award for Applied Chemistry

Mr. M M Qader receives the Kandiah Memorial Award for Basic Chemistry

Ms. K S S P Fernando receives the Kandiah Memorial Graduateship Award

Prof. S P Deraniyagala receives the Distinguished Service Award

Section of participants

Technical Sessions


Ms. A Kuganesan


Ms. A G Guruge


Mr. U L A S Perera


Ms. S M Abdullah


Ms. H D S Ishara


Mr. J M A R B Jayasinghe


Ms. M A T P Manthrirathna


Ms. D V C D Madushani


Ms. H M H S Bandusena


Ms. A S N Kurian


Ms. L A Wijesekara


Ms. C Weththasinghe


Section of participants

Annual Dinner & Induction of New President, Dr. Poshita Premaratne


Section of participants


Dr. Poshita Premaratne was ceremonially inducted as the new President by presenting him the President's Medal.


Section of participants


Section of participants

Kandiah Memorial Award for Basic Chemistry - 2017

Mohomed Mallique Qader graduated with B.Sc. First Class Honours Degree from the Open University of Sri Lanka (OUSL) in 2013. During his undergraduate studies, he received six awards including a special award for the excellence in organic chemistry and related subjects from the OUSL. In 2014, he joined the Natural Product research group of the National Institute of Fundamental Studies (NIFS), Kandy as a Research Assistant. He is conducting research on "Chemistry and Bioactivity of Sri Lankan Flora with special reference to Microbial Natural Products" under the supervision of Professor Lalith Jayasinghe and Professor N. Savitri Kumar. He has registered for a Ph.D. degree in the field of Microbial Natural Products at the University of Peradeniya, Sri Lanka. He has five international peer reviewed publications and fourteen communications presented in international and national symposia. In 2017, he was awarded the Erasmus Mundus Doctorial Mobility Fellowship by the European Commission to undertake part of his Ph.D. studies at the University of West of Scotland, UK.

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Chemistry and bioactivity of secondary metabolites produced by endophytic fungi of three Sri Lankan medicinal plants

M M Qader

National Institute of Fundamental Studies, Kandy

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Sri Lanka is recognized as one of the twenty-five biodiversity hotspots in the world due to the diverse biodiversity of fauna and flora. When considering the flora in Sri Lanka, recent surveys show that Sri Lanka's natural vegetation covers about 25% of the total land area.[1] Plants are bonded to human lives because of their widespread benefits, specially their ability to cure many diseases in traditional medicine. In this regard Sri Lanka has a long history of the use of medicinal plants in improving quality of human lives.

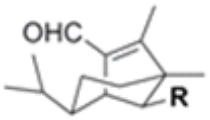
Plants have been used in traditional medicine and are the main source for preparations used in Ayurveda. More than 80% of the world populations still depend on plant based products for their primary health care due to the less toxicity, less chronic effects and they are environmentally friendly, while synthetically produced compounds are resistant to the infections, can cause autoimmune disorders and degenerative disorders like aging.[2] Therefore plant based medicines play a major role in economy and the quality of life style. Aspirin (acetyl salicylic acid, from the bark of *Salix* and *Populus*), salicin (*Salix alba* L.), and morphine (*Papaver somniferum* L.) are some of the most famous and commercially important drugs derived from plants.[3]

Fungi have been closely associated in human life as they are used as food, beverages and in traditional medicine. With the advancement of microbiology, they become useful as enzymes, biological controllers, antibiotics and other pharmacologically active products.[3] Fungi are categorized into two groups depending on their presence in plant tissues, which are endophyte and epiphyte. Epiphytes are microorganisms that grown on or attached to a plant, while endophyte spend the whole or part of its life cycle colonizing intercellular or intracellular inside the healthy tissues of the host plant.[4] Endophytes are found in seeds, fruits, stems, roots, leaves, buds, xylemand bark.[5] Fungi and bacteria are the most available organisms as endophytes[6], among them fungi are mostly studied organisms.[7] Endophytes are not host specific and are not limited to particular host range.[6] The number of endophytic species associated with plants can reach several hundred.[5] Furthermore, it has been reported, that endophytes are found in marine algae[8], mosses and ferns[9]. Plants infected with endophytes are often healthier than endophyte-free plant species. Because endophytes are able to produce phytohormones, growth promoting substances, enhance the tolerance level of the host plants against environmental stresses and provide protection against herbivores microbial pathogens by producing bioactive metabolites.[4-6] During their symbiotic relationship host plant provides the favorable microhabitat for the survival of the endophyte and supply nutrition for their development. During the co-evolutionary process, endophytes has been adapted themselves to the microenvironment of their host plant by genetic variation, including uptake of plant DNA genomes into their own genomes[5-10]. Hence endophytic

fungi have the ability to produce same or similar phytochemicals originally associated with the host plants. Taxol is the first major group of million dollar anticancer agent originally found in the bark of *Taxus brevifolia* in 1971. After discovering of the similar drug from the endophytic fungi *Taxomyces andreanae* in 1993, immense interest in studying natural products from microorganisms, especially in endophytic fungi has gained.[7,10] Most of the drugs which are actively used in clinically (cholesterol lowering statins: lovastatin; anticancer: vincristin; antibiotics: cephalosporins) are originated from fungi.[11] Present study was initiated to investigate the secondary metabolites produced by the popular medicinal plants *Costus speciosus* (Costaseae) and famous fruits as well as medicinal plants *Garcinia mongostana* (Guttiferae) and *Flacourtia inermis* (Flacourtiaceae).

Costus speciosus is consumed as a salad in main meals for control of type II diabetes mellitus mainly in Asian countries. Aqueous and methanolic extracts of *C. speciosus* showed the ability to decrease the plasma and serum glucose levels significantly.[12] Rhizome is the major source for diosgenin and shows antidiabetic nature and used to treat type II diabetes mellitus.[13]

Concerning the above facts, the studies were focused to isolate an endophytic fungus from the leaves of *C. speciosus* and identified as *Bipolaris sorokiniana* (99%: NCBI Accession No: KJ767094.1) based on 18S rRNA sequence. This is the first report of the isolation of *B. sorokiniana* from *C. speciosus.* Fermentation of the fungus in PDB media for four weeks and extraction of the broth and the mycelium results EtOAc and MeOH crude extracts. EtOAc extracts of mycelium and broth showed similar patterns in TLC analysis. Therefore both EtOAc extracts were pooled together. EtOAc crude extract found to be the bioactive extract for antifungal activity[14] against *Cladosporium cladosporioides*, DPPH radical scavenging activity[15] (IC50: 346.5 ppm), *Artemia salina* toxicity[16] (LC50: 407 ppm), lettuce seed germination activity[17] (100% inhibition: 400 ppm) and a-amylase enzyme inhibitory activity[15] (IC50: 827.1 ppm). Chromatographic separation of EtOAc crude extract over silica gel, Sephadex LH-20 and final purification by PTLC furnished rare sesquiterpenes, helminthosporal acid (**1**) and helminthosporol (**2**) (Figure 1). Both compounds **1** and **2** showed toxicity towards *Artemia salina* (LC50: 27.1, 28.3 ppm, respectively) and inhibited 100% lettuce seed germination at 62.5 ppm and specifically inhibited the growth of hypocotyls at 45.5 and 28.6 ppm, respectively, while inhibiting the radical growth at 31.6 and 20.6 ppm respectively. Compound **1** inhibited the growth of plant pathogenic fungi *C. cladosporiodes* at minimum concentration of 31.3 ppm. Interestingly, compound **1** was initially laboratory synthesized by oxidation of helminthosporal with Ag_2O.[18] This is the first report on isolation of helminthosporal acid from a natural source and complete assignment of the molecule by ^{1}H NMR and ^{13}C NMR data.



1 = **R** = COOH
2 = **R** = CH_2OH

Figure 1: Structures of helminthosporal acid (**1**) and helminthosporol (**2**)

Garcinia mangostana is used in traditional medicine in Asia for many ailments. Especially fruit hull, bark, roots, and leaves are used to treatment skin infections and wounds and antiparasitic treatments in dysentery and chronic ulcers. Further, *G. mangostana* are known to have strong anti-inflammatory, antiallergy, antimicrobial, antioxidant, cytotoxic, anticancer and immunomodulatory properties.[19] *Garcinia mangostana* contains polyphenol type compounds called xanthones as major bioactive compounds. More than 68 types of xanthone derivatives have been reported from fruits, seeds, stem, heartwood and latex, which has significant antioxidant, antifungal, antibacterial, cytotoxic, anti-inflammatory, anti-HIV and antiulcer activity.[19,20]

Accordingly, fruits of *G. mangostana* were subjected to above similar procedure. An endophytic fungus, *Penicillium citrinum* (100%: NCBI Accession No: KP013076.1) was isolated from the pericarp of the fleshy edible fruit. Fungal crude extracts of EtOAc and MeOH showed active against DPPH antioxidant activity (105 and 258.4 ppm, respectively) and *Artemia salina* lethality activity at 420.8 and 250 ppm, respectively. None of the extracts showed activity against antifungal, lettuce seed germination and a-amylase enzyme inhibitory activity. Purification of EtOAc crude extracts over chromatographic methods resulted rare polyketide-peptide hybrid compound GKK1032B (**3**) and citrinin (**4**) (Figure 2) in high yield (2.3 g/8 L).

This is the first report of isolation of fungus *P. citrinum* from fruits of *G. mangostana.* Antitumor

antibiotic GKK1032B was first isolated from unidentified *Penicillium* sp. in 2001 together with GKK1032A1 and GKK1032A2.[21,22] Subsequently GKK1032B has been isolated from an endophytic *Penicillium* sp. isolated from *Melia azedarach* and *Murraya paniculata*.[23] This is the third report of the isolation of GKK1032B and the first report of the fungal source up to the species level identification. Therefore it can be suggested that the two unidentified *Penicillium* strains in the earlier papers are to be *P. citrinum*, since the production of this class of secondary metabolites have not been reported from any other *Penicillium* speciesthus far. GKK1032 is a family of a series of biologically active fungal metabolites produced by unknown *Penicillium* sp.[23] This includes GKK1032 A1, A2 and B. GKK1032 compounds show antimicrobial, anticancer and antitumor activities against cancer cell lines. Members of the GKK1032 family show unique structural features like, 12 or 13 membered macrocyclic ether containing ring, 1,4-disubstituted phenyl group and γ- lactam or succimide group.[24] Oikawa and the group demonstrates the isotope feeding experiments with [1-^{13}C] acetate followed by [2-^{13}C] resulted the biosynthesis of the backbone constructed by the polyketide pathway. Further, this confirms that the starter unit is acetate. During this polyketide pathway three carboxylic acid systems have been reduced, this is biosynthetically rare incident in polyketide metabolites. Further, five methyl groups in the backbone are introduced by the polyketide synthetase (PKS) enzymes. The remaining nine carbon containing group is derived from the peptide, L-tyrosine.[19] As polyketide derived compounds are structurally diverse and complex, multifunctional enzymes are often involved in synthesis.[25] Here, two hybrid enzymes PKS and non-ribosomal peptide synthetase (NPRS) are responsible for the production of nitrogen containing polyketides. Citrinin (**4**) (Figure 2), a nephrotoxin, mycotoxin which cause damages to kidneys. It is consistently produced by *P. citrinum*[26] and Pastre *et al.*[23] described the isolation of citrinin together with GKK1032B. The isolation of citrinin besides GKK1032B appears to support the validity of the fungal identification. Compound **4** is a quinone methide with two intramolecular hydrogen bonds. The H bonding between phenol and keto group links to the carbonyl group of the carboxylic group, give its natural fluorescence activity.[26]

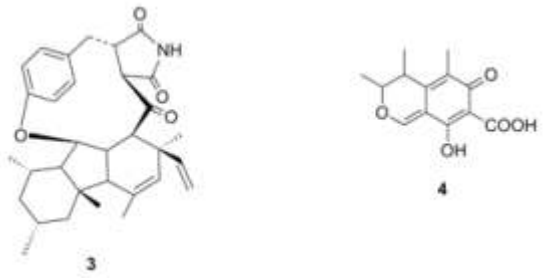


Figure 2: GKK1032B (**3**) and citrinin (**4**)

Fruits of *F. inermis* are commonly consumed due to its astringent and sour flavor and their medicinal value.[27] Fruits and leaves of *F. inermis* are used to treat pruritus scabies in indigenous medicine.[28] Similarly, *Fusarium decemcellulare* (98%: NCBI Accession No. KM277988.1) was isolated from the sterilized fruits of *F. inermis.* The crude extracts show less activity for the above bioassays. The crude extracts were chromatographed and furnished high polar, highly UV active (= 254 nm) shikimic acid (**5**) (Figure 3) which is also less active for the tested bioassays. Compound **5** is used to manufacture influenza drug, Oseltamir phosphate: which is effective against H5NI influenza virus (bird flu).[29] Compound **5** is especially responsible in the biosynthesis of aromatic amino acids (phenylalanine, tyrosine, tryptophan) as benzene ring is formed through shikimate pathway.[30] Ergosterol (**6**) (Figure 3), a sterolic compound commonly produced by plants and fungi and was able to isolate from this study.

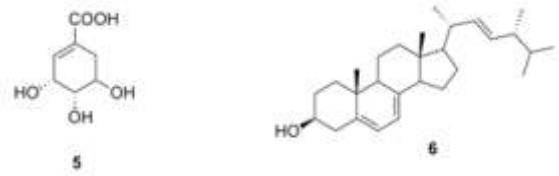


Figure 3: Structures of shikimic acid (**5**) and Ergosterol (**6**)

In conclusion, this study demonstrates the beneficial properties of fungal metabolites of endophytic fungi isolated from medicinal plants in possible applications in medicine and agriculture. So far there are a few studies reported on endophytic fungi of Sri Lankan flora. Hence it is useful to explore the chemistry of endophytic fungi associated with Sri Lankan flora for their potential applications in agriculture and medicine.

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Kandiah Memorial Award for Applied Chemistry - 2017

Cheka Lumbini Kehelpannala graduated from the University of Peradeniya with B.Sc. Special Degree in Chemistry (Second Class Honours - Upper Division) in 2013. Subsequently she joined the Natural Products research group at the National Institute of Fundamental Studies (NIFS) as a Research Assistant where she conducted research on "Chemistry and Bioactivity of Sri Lankan Flora with special reference to Microbial Natural Products". She was awarded M.Phil. degree in Natural Product Chemistry in 2016 from the University of Peradeniya. The title of her thesis was "Naphthoquinones produced by the fungus *Monacrosporium ambrosium* from Tea (*Camellia sinensis*) in culture media; biological activity, effect on caffeine and fungal growth in the presence of trace metal ions" which was carried out under the supervision of Professors N. Savitri Kumar and Lalith Jayasinghe at NIFS. Based on her research work at NIFS she has presented three abstracts and submitted two manuscripts for peer reviewed journals in addition to the publication that appeared in *Chemistry Letters* from her undergraduate research work. She has received the MedChemComm Poster prize awarded by the Royal Society of Chemistry for her poster titled "Shot hole borer beetle of tea: A fungal farmer".

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Study of the biological acitivities of metabolites produced by *Monacrosporium ambrosium* and of *M. ambrosium*, ectosymbiote of shot hole borer (*Xyleborus fornicatus*) beetle of tea (*Camellia sinensis*)

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Fungi have been exploited as a potential source of novel compounds of benefit to human population with the discovery of the potent antibiotic penicillin produced by *Penicillium notatum*.[1] Since then the investigation of secondary metabolites from fungi has aroused worldwide interest. In general, secondary metabolites are bioactive compounds of low molecular weights, which are produced as families of related compounds during restricted parts of the lifecycle. Frequently these metabolites are produced at specific stages of morphological differentiation of the organism. These secondary metabolites are not always essential for the survival and growth of the organism. However, many of the secondary metabolites produced by fungi have been found to beneficial to humans. Lovastatin, the first statin drug used to inhibit the HMG-CoA reductase which leads to the decrease in production of cholesterol within human bodies was first isolated from the fungi *Aspergillus terreus* and *Monascus rubber*.[2] Fingolimod, a synthetic potent immunosuppressant drug for multiple sclerosis is based on the fungal secondary metabolite Myriocin isolated from the entomopathogenic fungus *Isaria sinclairii*.[3] Caspofungin, the first echinocandin antifungal compound is a semi-synthetic, water soluble, lipo-peptide derivative of Pneumocandin B0 first isolated from the fungus *Glarea lozoyensis*.[4] Beauvericin, a mycotoxin with potential use in medicine and as a pesticide was first isolated from the fungus *Beauveria bassiana*.[5] These findings show that fungi are excellent sources of novel bioactive compounds which are beneficial for humans.

Monacrosporium ambrosium (Ambrosia fungus, syn. *Fusarium ambrosium*) is the ectosymbiote of shot hole borer (*Xyleborus fornicatus*) (SHB) beetle which causes serious damage to the tea plantations in Sri Lanka. The beetle attacks tea stems by boring galleries in the stems. Adult female SHB beetles introduce spores of *M. ambrosium* into the galleries. The beetle lays eggs inside the galleries and the larvae emerging from eggs feed on the spores of the fungus which maybe the only or major food source for the larvae of SHB beetles.[6] *Monacrosporium ambrosium* grows on gallery walls where larvae reside as a fine, white, frost-like dust. It is also believed that the fungus provides the steroidal moulting hormone required to complete the lifecycle of the beetle.[7] SHB beetles are therefore one of the few examples known of agriculture, or fungiculture and "fungus farmers" in the animal kingdom.[8-10]

The objective of the study was to determine the structures of the secondary metabolites produced by *M. ambrosium* in laboratory culture media, and to

investigate their biological activity to understand the role of these metabolites in SHB beetle infestation of tea.

SHB beetles were collected from SHB infested pencil thick tea stems of the tea cultivar TRI 2025 from the Tea Research Institute (TRI)-Sub Station, Hantana, Kandy and isolated in the laboratory at the National Institute of Fundamental Studies (NIFS). Live SHB beetles were surface sterilized and allowed to move on potato dextrose agar (PDA) plates until the mycelium of *M. ambrosium* appeared. *M. ambrosium* was sub cultured until a pure culture was obtained. Pure cultures of *M. ambrosium* were used to culture the fungus in large scale (400 ml x 60 flasks) in potato dextrose broth (PDB). The flasks were incubated with occasional shaking at room temperature for 28 days. The culture broth was filtered and extracted with ethyl acetate (EtOAc). The mycelium was extracted with EtOAc and then with methanol (MeOH) with the aid of a sonicator. The two EtOAc extracts were combined (Extract A) since their TLC patterns were similar. Extract A was separated by chromatographic techniques. The crude extracts of *M. ambrosium* were subjected to bioassays to test for cytotoxicity using the brine shrimp (*A. salina*) lethality assay[11], phytotoxicity using lettuce (*L. sativa*) seed germination assay[12], α-amylase inhibitory activity assay[13] and anti-fungal activity against *Cladosporium cladosporioides* by the TLC bioautographic method[14]. Agar dilution assay[15] was performed with Extract A against two endophytic fungi, *Pestalotiopsis camelliae* and *Phoma multirostrata* isolated from surface sterilized, pencil thick pieces of TRI 2023 healthy stems collected from TRI-Hantana. Bioinhibitory activity of *M. ambrosium* against three endophytic fungi, *Bipolaris sorokinana* (from *Costus speciosus*), *Daldinia eschscholizii* (from *Phyllanthus acidus* L.) and *Glomerlla magna* (from *Piper betel* L.) was investigated.

Extract A was subjected to chromatographic separations which yielded six intensely coloured naphthoquinoes. First, the separation was carried out using normal phase gravity column chromatography using Hexane:EtOAc:MeOH and Hexane:CH_2Cl_2:MeOH solvent systems in the increasing order of polarity. Further separations were carried out using size exclusion chromatography with Sephadex LH-20, PTLC and HPLC. The separated compounds were identified as dihydroanhydrojavanicin (**1**), anhydrojavanicin (**2**), javanicin (**3**), 5,8-dihydroxy-6-methyl-7-(2-oxopropyl)naphthalene-1,4-dione (**4**) anhydrofusarubin (**5**) and solaniol (**6**) (Figure 1) by detailed analysis of NMR and MS data as well as by comparison with reported data. These compounds have not been previously isolated from *M. ambrosium*.

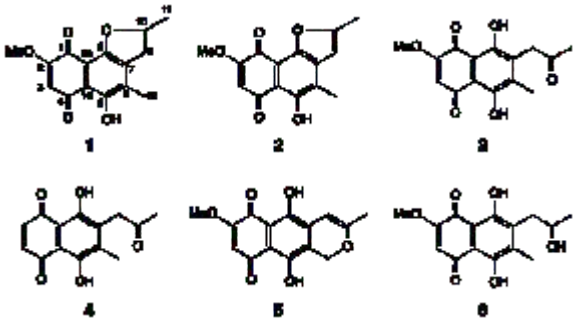

Figure1: Chemical structures of compounds 1-6

The following bio-inhibitory studies were carried out only for Extract A, because pure samples of metabolites isolated after many fractionations were sufficient only for structural studies using spectroscopic techniques. Extract A was found to possess many compounds with antifungal activity against *C. cladosporioides*. Three days after spraying the spore suspension of *C. cladosporioides* on the TLC plates with separated compounds of Extract A and incubation, several white spots on a green background of *C. cladosporioides* were observed and indicated the presence of antifungal compounds in the crude EtOAc extract. Many naphthoquinones have been found to possess fungitoxic properties against *C. cladosporioides* and *Candida albicans*.[16,17]

Brine shrimp lethality of the extracts was found to be concentration dependant. The toxic effect of the extracts on brine shrimps declined with dilution. EtOAc extract of broth of ambrosia mycelium showed the highest lethality for brine shrimps (LD_{50} 702 ppm) while EtOAc and MeOH extracts of mycelium showed low activity (LD_{50} 1395 ppm and 993 ppm respectively). LD_{50} of the positive control Atropine is reported to be 686 µg/ml.[18] Some naphthoquinones have been shown to possess moderate antitumor properties.[17] Culture filtrates of some strains of *Fusarium solani* have been shown to cause toxic effects on brine shrimps.[19]

The inhibition of root and shoot elongation of the seeds of *L. sativa* at 250 ppm of the EtOAc extract of *M. ambrosium* culture broth was 100%. Shoot and root elongation of lettuce seeds was completely inhibited by the EtOAc extract of the mycelium of *M. ambrosium* at 1000 ppm. Phytotoxic activity was lowest with the MeOH extract of the mycelium of *M. ambrosium.* Root

and shoot elongation of lettuce seeds was completely inhibited by the MeOH extract of the mycelium of *M. ambrosium* at concentrations of 2000 ppm and 4000 ppm, respectively. The positive control Abscisic acid displayed 100 % inhibition of root and shoot growth at 10 ppm. Phytotoxic activities of some naphthoquinones have been reported previously.[20] Naphthoquinones metabolites such as javanicin, fusarubin, anhydrofusarubin and botricoidin of the fungus, *Fusarium decemcellulare* have been shown to possess phytotoxic activity against pea seedlings.[20] α-Amylase inhibitory activity of the crude extracts of *M. ambrosium* was found to be very low. Amylase enzyme was not inhibited completely by the EtOAc and MeOH extracts of the *M. ambrosium* culture broth and mycelium even at 5000 ppm.

The effect of Extract A on the growth in PDA of two endophytic fungi, *P. camelliae* and *P. multirostrata* isolated from tea stems and *M. ambrosium* was tested using agar dilution assay. Inhibition (%) of growth after 7 days was calculated at 500 ppm and 1000 ppm of Extract A, and a control plate without Extract A by measuring the diameter of the fungal colonies. Triplicate assays were carried out. The EtOAc extract of *M. ambrosium* inhibited (100 % at 1000 ppm and 78.7 % at 500 ppm) the growth of the endophytic fungus *P. camelliae*. Growth of another endophytic fungus, *P. multirostrata* was also inhibited (31.0% at 500 ppm and 38.1% at 1000 ppm) although the effect was less pronounced than on *P. camelliae.* A very slight inhibitory effect (10.2 %) was observed on the growth of *M. ambrosium* at 500 ppm and 1000 ppm.

In the bioinhibitory study, endophytic fungi, *B. sorokinana*, *D. eschscholtzii* and *G. magna*, isolated at the NIFS, from *C. speciosus*, *P. acidus* L. and *P. betel* L., respectively, were grown competitively with *M. ambrosium* on PDA plates. Pieces (1 cm^2) of each fungus and *M. ambrosium* (1 cm^2) were placed on PDA media in petri plates (9 cm diameter) and incubated at room temperature for 7 days. The experiment was carried out in triplicate and observations were recorded during 7 days. *M. ambrosium* did not affect significantly the growth of *B. sorokinana*. The dark grey coloured colony of *B. sorokinana* was not inhibited and had grown towards the colony of *M. ambrosium*. Similarly, *M. ambrosium* did not affect the growth of *G. magna.* The dark grey coloured colony of *G. magna* had grown towards the salmon pink cloured colony of *M. ambrosium*. Both fungi grew well and one was not dominant over the other while *D. eschscholtzii* grew very rapidly and over grew the mycelium of *M. ambrosium* by 2 days. After 7 days the mycelium of *M. ambrosium* was almost completely obscured by the rapidly growing light greyish white mycelium of *D. eschscholtzii.* The growth rate of *M. ambrosium* was slower than in a pure culture of this fungus. *D. eschscholtzii* invaded the mycelium of *M. ambrosium. G. magna* did not affect the growth of *M. ambrosium*. It is of importance to note that the EtOAc extract of *M. ambrosium* containing naphthoquinones inhibited the growth of two endophytic fungi; *P. camelliae* and *P. multirostrata* residing in tea stems, while the growth of three endophytic fungi isolated from three medicinal plants in Sri Lanka were not inhibited by *M. ambrosium* in laboratory culture media.

Fungicidal activity of many naphthoquinones has been reported by several studies. Lawsone has been found to have a significant antifungal effect.[21] Plumbagin, which has been reported to possess a wide variety of bioactivities, is a good antifungal agent.[22] A novel fungitoxic naphthoquinone, Eleutherinone has been isolated from *Eleutherine bulbosa*.[16] Synthetic naphthoquinones such as 2-hydroxy-3-chloro-1,4-naphthoquinone, 2-(N-acetyl)-acetamido-3-chloro-1,4-napthoquinone and 2-(*N*-acetyl)-acetamido-3-chloro-1,4- napthoquinone have been found to posses potent antifungal activity against *Candida albicans*.[23]

The results of the study suggest that *M. ambrosium* produces antifungal naphthoquinones which are able to inhibit the growth of the two endophytic fungi living within tea stems. *M. ambrosium*, is therefore not only the food and sterol source of the beetle, but is also a producer of fungal inhibitory substances which may help to keep SHB galleries free of other fungi.

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The first GIC Student privileged to receive Dr & Mrs. Sentheshanmuganathan Family Bursary offered by the Institute of Chemistry Ceylon

Ms Samurdhika Chathurangani was one of the first recipients of the above bursary which was awarded to her while she was following the Graduateship Programme in Chemistry (GIC) at the Institute of Chemistry Ceylon (ICHEMC).

Samurdhika is currently working as a Trainee Chemist at 4ever Skin Natural (Pvt.) Ltd, BOI industrial park, Kandy, Sri Lanka. In a letter of appreciation written to Dr. Sentheshanmuganthan, she had greatfully acknowledged how the financial support received had helped her very much to complete her graduateship studies at the ICHEMC successfully. In fact, she graduated with Second Class (Upper Division) at the convocation ceremony held in February 2017.

Dr. Sentheshanmuganathan with his grandchildren

This bursary was made possible by a generous donation of 10,000 Canadian Dollars initially and further some of 10,000 US Dollars subsequently by Dr Sentheshanmuganthan, one of the oldest Members of ICHEMC, now domiciled in Canada.

ICHEMC was established in 1971 as the successor to the Chemical Society of Ceylon. Dr Sentheshanmuganathan was the President of the Institute of Chemistry Ceylon in 1972 – 1973, succeeding the first President of the ICHEMC, Dr M.A.V. Devanathan. He received an Honorary Fellowship of the ICHEMC in 2015 at the 44th Annual Sessions of the ICHEMC. It may be significant to mention that he was one of the pioneers of the popular Diploma in Laboratory Technology in Chemistry (DLTC) programme conducted at the ICHEMC; he was appointed the director of this programme and subsequently became its coordinator.

On behalf of the staff and Members of the ICHEMC, we wish Dr Shentheshanmuganathan and his extended family all the very best in all their future endeavours.

Kandiah Memorial Graduateship Award - 2017

K.S. Shivanthi Palika Fernando is a graduate of the College of Chemical Sciences, Institute of Chemistry Ceylon. She also holds a BAMS degree from the Institute of Indigenous Medicine, University of Colombo and currently works as the Medical Officer in Charge of the Dorakumbura Ayurvedic Central Dispensary at Matale. The work she has carried out for her M.Phil. degree at University of Sri Jayewardenepura on the scientific basis for the ethnomedical usage of *Artocarpus heterophyllus* leaves in the treatment of diabetes has resulted so far one international publication and four conference presentations. This research was supervised by Professor A. M. Abeysekera, Professor U. G. Chandrika, Dr. C. Padumadasa and Dr. A. K. E. Goonathilake of the University of Sri Jayewardenepura.

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A study of the chemistry of *Artocarpus heterophyllus* Lam. leaves and identification of active antioxidant and hypoglycemic fractions/ compounds

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Introduction

Diabetes mellitus is a syndrome of chronic hyperglycemia due to relative insulin deficiency, resistance, or both.[1] During the last twenty years, the prevalence of the disease has increased all over the world and it now affects all populations. The International Diabetes Federation (IDF) estimated that in 2013 worldwide 387 million people were suffering from diabetes mellitus with projections that the number will increase to 592 million by 2035.[2] Long-term complications of diabetes include retinopathy with potential loss of vision, nephropathy leading to renal failure, peripheral neuropathy with risk of foot ulcers leading to amputations and Charcot joints, autonomic neuropathy causing gastrointestinal, genitourinary, and cardiovascular symptoms and sexual dysfunction.[3] Further, diabetic patients have an increased rate of atherosclerotic, cardiovascular, peripheral arterial and cerebrovascular disease, hypertension and abnormalities of lipoprotein metabolism.[3] Mortality and morbidity are increased due to these complications. Currently insulin and various oral antidiabetic agents are used as monotherapy or in combination to achieve better glycemic regulation. Many of these oral antidiabetic agents have several serious adverse effects and most of drugs show development of resistance.[4] It is still a challenge to manage diabetes mellitus without any side effects. The search for new drugs which are safer and more effective is an active area of research. *Artocarpus heterophyllus* is a well-known plant which belongs to family Moraceae and its leaves are used ethnomedically in Sri Lanka for the control of diabetes mellitus. The antidiabetic and hypoglycemic effects of the aqueous leaf extract have been demonstrated in animal models and in human subjects.[5-7] The hypoglycemic effect of the ethyl acetate fraction of aqueous leaf extract has also been demonstrated in animal models.[8-10] In this paper, we report the potential of *A. heterophyllus* leaves for the treatment of diabetes mellitus through its hypoglycemic activity of the fractions of ethyl acetate fraction of the water extract and its chemical analysis.

Methodology

Plant material

Senescent leaves of *A. heterophyllus* were collected from a plant (cultivar *Waraka*) growing in a home garden in Wijerama in the Colombo district. Voucher specimen (B7/006(SJP)) has been deposited in the herbarium, Department of Botany, University of Sri Jayewardenepura. The leaves were washed, air-dried for 3 hours and crushed using a mechanical blender and was used immediately for extractions.

Extraction

A sample of senescent leaves of *A. heterophyllus* (500 g) was extracted by refluxing with 2500 mL of distilled water in a 5 L round bottom flask for 4 hours. After filtration, the extract was concentrated and excess ethanol was added to precipitate the high molecular weight fraction. The mixture was filtered, concentrated and extracted with ethyl acetate. Combined ethyl acetate extract was concentrated to produce a brownish-black sticky solid (1.2 g) (EA/W). This was repeatedly done to obtain 14 g of EA/W.

Fractionation of EA/W

EA/W (14 g) was fractionated by Sephadex LH-20 column chromatography. Column was eluted with 5 different solvents and fractions were collected separately. Fraction 1 was eluted with dichloromethane/hexane 4:1 (1 L) and fraction 2, 3, 4 and 5 were eluted with dichloromethane/acetone 3:2 (1 L), dichloromethane/acetone 1:4 (0.9 L), dichloromethane/ methanol 1:1 (1 L) and methanol (1 L) respectively. The weights of each fraction after evaporation of the solvent were obtained. Distribution of compounds were analyzed by TLC (Silica (GF 254) with solvent systems; ethyl acetate: dichloromethane: methanol: formic acid (58:38:2:2) and ethyl acetate: formic acid: glacial acetic acid: water (100:11:11:27).

***In vivo* studies**

Animal model

Male Wistar rats approximately 8 - 12 weeks old, weighing 150 - 300 g were used for the study. The rats were maintained and handled in accordance with the standard guide for the care and use of laboratory animals and necessary skills for rat handling were obtained before commencing the research. Rats were individually identified by colour markings on their body.

For *in vivo* studies on normoglycemic rats, 42 rats were divided into 7 groups (groups A –G) and for *in vivo* studies in the diabetic model experiment 48 rats were divided into 8 groups (groups H – O). The animals used were kept fasted overnight before commencement of experiment.

Induction of diabetes mellitus

Rats in groups H – O were diabetized using nicotinamide (120 mg/kg body weight) and streptozotocin (60 mg/kg body weight) according to a previously published method.[11-15]

Effect on blood glucose levels in normoglycemic rats

Animals in groups A – G were fasted overnight and fasting blood glucose levels of the rats were measured. After that group A served as control and received water. Group B received a single dose of 50 mg/ kg body weight EA/W. Groups C, D, E, F and G received a single dose of fraction 1,2,3,4 and 5 (50 mg/ kg body weight), respectively which were obtained from Sephadex LH-20 column. All samples were given orally. After that blood glucose levels were measured at 1 hour, 2 hours and 3 hours after administration of sample. Blood was obtained from the tail vein. Blood glucose was measured using a glucometer (Accu-Check glucometer).

Effect on fasting blood glucose levels in diabetic rats

Same procedure as above was carried out for groups H –N and Group O rats were administered with glibenclamide at 5 mg/ Kg body weight.

Effect on glucose tolerance in normoglycemic rats

After 2 weeks of the experiment using normoglycemic rats, animals in groups A – G were kept fasted overnight and fasting blood glucose levels of the rats were measured. After that group A served as control and received water. Group B received a single dose of 50 mg/kg body weight EA/W. Groups C, D, E, F and G received a single dose of fraction (50 mg/kg body weight) 1, 2, 3, 4 and 5, respectively which were obtained from Sephadex LH-20 column. All samples were given orally. After 1 hour blood glucose level was measured and a glucose load (3 g/kg body weight) was administrated. After that blood glucose levels were measured at 1 hour, 2 hours, and 3 hours after the administration of glucose load. Blood was obtained from the tail vein. Blood glucose was immediately measured using a glucometer (Accu-Check glucometer).

Effect on glucose tolerance in diabetic rats

After 2 weeks of the experiment in diabetic rats, animals in groups H – O were kept fasted overnight and fasting blood glucose levels of the rats were measured. Same procedure was carried out for groups H –N while Group O rats were administered with glibenclamide at 5 mg/ Kg per body weight.

***In vitro* studies**

2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay, superoxide anion radical scavenging assay, α- glucosidase enzyme inhibition assay,

antiglycation activity and anti-inflammatory activity of EA/W and fractions 1-5 were carried out according to previously published methods.[11-15] All the experiments were carried out in triplicate.

Compound Isolation

Fractions 3 and 4 showed the highest activity in *in vivo* and *in vitro* assays. These two fractions also showed similar chemical profiles in thin layer chromatographic studies. Thus, fractions 3 and 4 were combined and subjected to compound isolation. Combined fraction (5.0 g) was chromatographed on MCI gel column chromatography to produce 17 fractions (M1 – M17). Fraction M3 (1.2 g) upon further chromatography produced compound 1 (3.3 mg) and 2 (6.2 mg). Fractions M2 (0.2 g) and M4 (1.0 g) upon further chromatography produced compound 3 (3.1 mg) and compound 4 (4.3 mg), respectively. All compounds were characterized by ^{1}H NMR, ^{13}C NMR, IR, UV-visible spectroscopy, EI and FAB spectrometry in positive ion mode.

Results and Discussion

EA/W and fractions 1-5 were screened for *in vivo* hypoglycemic and antidiabetic activities. Treatment of the rats with nicotinamide and streptozotocin resulted in elevated plasma glucose levels consistent with diabetes (>120 mg/ dL), whereas non-treated rats without nicotinamide and streptozotocin had normal glucose levels (< 120 mg/dL). Each fraction was tested for its effect on the blood glucose levels of fasted normal and diabetic rats. None of the fractions caused hypoglycemia on normal rats. However, there was significant ($p < 0.001$) reduction in the blood glucose level during the first three hours after giving the fractions 3, 4 and 5 to diabetic rats (Figure 1). Figure 2 clearly show that the highest reduction occurs at second hour after administration of the fractions. Further, it shows fraction 3, 4 and 5 have significant reduction ($p < 0.001$) with respect to control group. Of the three fractions, fraction 4 showed the highest hypoglycemic activity. Fractions 3, 4 and 5 were also the most active in the glucose tolerance test carried out on both normoglycemic and diabetic rats (Figures 3 and 4). However, fraction 3 was the most active in this assay. In both assays fractions 3, 4 and 5 at 50 mg/kg body weight showed activity of the same order as glibenclamide at 5 mg/kg body weight. Fraction 4 was found to be the most active fraction in all the *in vitro* assays.

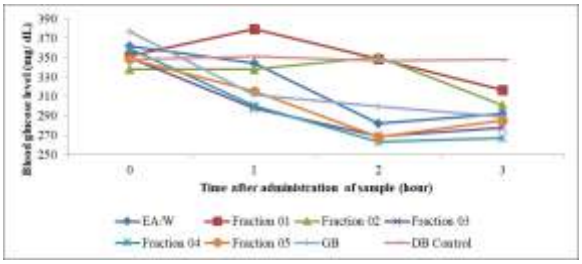

Figure 1: Variation of blood glucose levels with time in diabetic rats after administration of fractions of EA/W. (Value at t=0 correspond to fasting blood glucose level)

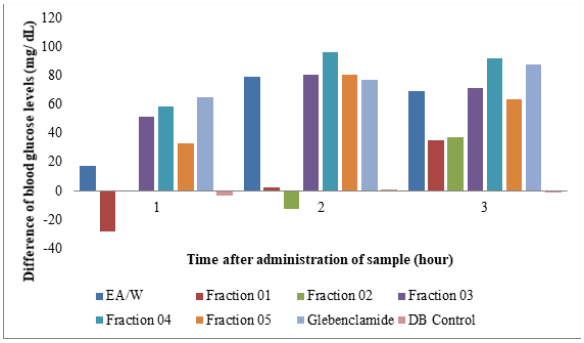

Figure 2: Reduction in blood glucose levels with time in diabetic rats after administration of fractions of EA/W.

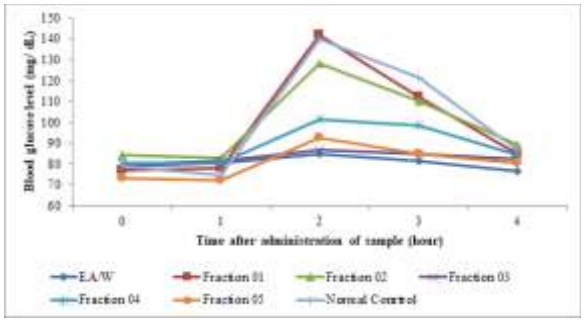

Figure 3: Variation of blood glucose levels of normoglyceamic rats with the time after administration of sample followed by glucose load.
Value at t=0 correspond to fasting blood sugar level.

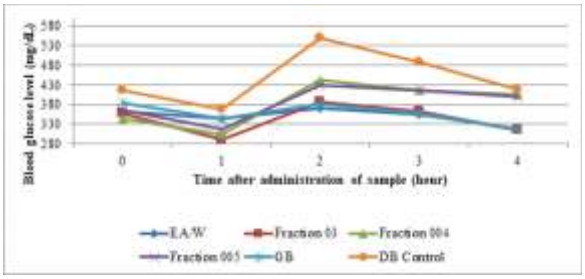

Figure 4: Variation of blood glucose levels of diabetic rats with time after administration of sample followed by glucose load.

Although the composition of the three fractions were different from each other and from EA/W as

analyzed by thin layer chromatography, there are no significant difference ($p>0.01$) in the activities. This suggests that EA/W contains many different compounds having approximately the same activity. When comparing all the *in vivo* results we can clearly see that optimum time of action is at the end of the 2nd hour after administration of sample.

EA/W and five fractions were subjected for *in vitro* antioxidant, antiglycation, α-glucosidase inhibition and anti-inflammatory assays the results of which are given in Table1. Fraction 4 was found to be the most active fraction in all the *in vitro* assays. These results indicate that the hypoglycemic activity of *Artocarpus heterophyllus* senescent leaves may be partly due to α – glucosidase inhibiting activity. Further its antioxidant activity and antiglycation activity (even though lower than rutin) may contribute to reducing the complication arising from diabetes mellitus.

Table 1: *In vitro* biological activity results of EA/W and its fractions

	DPPH radical scavenging assay IC_{50}(µg/ mL)	**Superoxide radical scavenging assay % Inhibition**	**Antiglycation assay IC_{50}(µg/ mL)**	**α- Glucosidase inhibitory assay IC_{50}(µg/ mL)**	**Anti-inflammatory assay IC_{50}(µg/ mL)**
EA/W	29.26 ± 0.71	90.60	Not active	1.9 ± 0.57	27.4 ± 2.0
Fraction 1	Not active*	<50	Not active	Not active*	71.3 ± 7.6
Fraction 2	108.34 ±0.45	<50	Not active	Not active*	70.7 ± 10.2
Fraction 3	29.31 ± 0.45	97	0.44 ± 0.01	51.0 ± 0.98	24.4 ± 3.8
Fraction 4	21.69 ± 0.31	98	0.30 ± 0.02	0.40 ± 0.01	16.9 ± 0.1
Fraction 5	Not active*	<50	Not active	8.60± 0.57	>100
Gallic acid	23.46 ± 0.43	-	-	-	-
Quercetin		100			
Rutin	-	-	0.18 ± 0.01	-	-
Acarbose	-	-	-	0.54± 0.01	-
Ibuprofen	-	-	-	-	11.8 ± 1.9

*Percentage inhibition was < 50 at 05 mg/mL concentration and hence IC_{50} value was not calculated
All values are expressed as IC50 ± SEM, n=3

The EA/W fraction was subjected to repeated column chromatography over Sephadex LH-20, MCI gel, preparative TLC and preparative HPLC to yield compounds 1, 2, 3 and 4 (Figure 7). Their structures were confirmed as 3, 4-dihydroxy-7-ene-megastigman-9-one (1), 13-Hydroxy-3-oxo-α-ionol (2), 4-hydroxy benzoic acid (3) and 3,4- dihydroxy benzoic acid (4), respectively by ^{1}H NMR, ^{13}C NMR, IR and UV-visible spectroscopy, EI and FAB spectrometry in positive ion mode. NMR spectroscopic data of compounds 1-4 are given in Table 2.

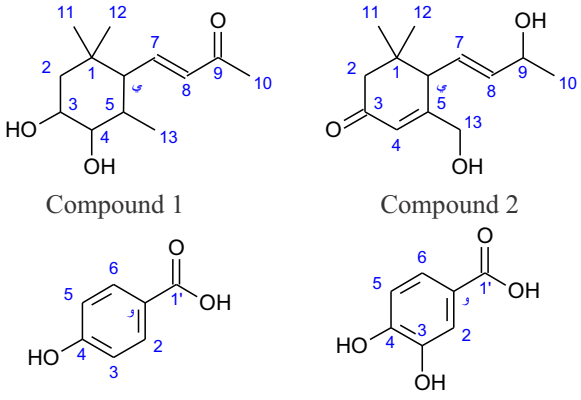

Figure 7: Structures of compounds 1-4

Table 2: NMR spectroscopic data of compounds 1-4.

	Compound 1		Compounds 2		Compounds 3		Compounds 4	
C NO	δ C	δ H	δ C	δ H	δ C	δ H	δ C	δ H
1	34.6		37.2		122.0		125.36	
1'					172.0		171.87	
2	41.8	1.47(dd)	49.2	2.10 (d)	132.7	7.86 (d)	145.86	
		1.71(dd)		2.49				
3	74.8	3. 57(s)	202.0		115.7	6.79 (d)	115.6	6.786 (d)
4	72.1	3.84(q)	122.3	6.1			123.66	7.404(dd)
5	31.3	2.10	168.3		115.7	6.79 (d)	150.79	
6	52.0	2.11	52.1	2.64 (d)	132.7	7.86 (d)	117.6	7.41 (S)
7	152.3	6.74 (dd)	127.4	5.60 (d)				
8	134.1	6.0 (d)	140.1	5.64 (t)				
9	200.9		68.8	4.25 (q)				
10	26.8	2.25 (s)	23.7	1.23 (d)				
11	24.0	1.08 (s)	27.3	1.02 (s)				
12	32.5	0.81	27.8	0.98 (s)				
13	17.3	0.85 (dd)	64.1	4.12 (d)				
				4.17 (d)				

Conclusion

The ethyl acetate fraction of the water extract of the senescent leaves of *A. heterophyllus* was fractionated into five fractions using Sephadex LH-20. Fractions 3, 4 and 5 were the most active in *in vivo* studies. Fraction 4 showed the highest activity in reducing blood glucose levels, while fraction 3 was the most active in the glucose tolerance test, indicating that fraction 3 contain a glucose uptake inhibitor. Fraction 4 exhibited high all *in vitro* activities. Fraction 4 showed highestα-glucosidase inhibition activity comparable to the standard drug acarbose and high DPPH radical scavenging activity than gallic acid. Analysis of the combined fraction 3 and 4 resulted in the isolation and characterization of four compounds 3, 4-dihydroxy-7-ene-megastigman-9-one (1), 13-Hydroxy-3-oxo-α-ionol (2), 4-hydroxy benzoic acid (3) and 3,4-dihydroxy benzoic acid (4). This study indicates that the observed hypoglycemic effect of EA/W appears to be due to a number of compounds acting together and not due to a single compound or an identifiable group of compounds. Further it appears that different modes of action such as hypoglycemic action, antiglycation, antioxidation and glucose uptake inhibition operates simultaneously in the water extract of the senescent leaves of *A. heterophyllus* justifying its use by diabetic patients in Sri Lanka. These results may be of potential use for the development of a modern anti diabetic drug from leaves of *Artocarpus heterophyllus*.

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Prof. M. U. S. Sultanbawa Award for Research in Chemistry - 2017

Ms. Anoosheya Kuganesan, a Graduate Chemist, has been selected for the Professor M U S Sultanbawa Award 2017. This award is made annually for the best paper presented at the Annual Sessions of the Institute of Chemistry Ceylon, for work carried out and completed in Sri Lanka.

Ms. Anoosheya Kuganesan obtained the Graduateship in Chemistry in 2013 with a Second Class Honours Upper Division. She was awarded a Research Assistantship by the College of Chemical Sciences (CCS), Institute of Chemistry Ceylon to carry out her postgraduate research. Her M.Phil. research project titled "Evaluation of bioactive compounds in pulp, peel and seed kernel of selected mango varieties from Sri Lanka" was supervised by Dr. G. Thiripuranathar, College of Chemical Sciences, Professor P. A. Paranagama, Department of Chemistry, University of Kelaniya, and Professor A. N. Navarathna, Department of Chemistry, University of Peradeniya. She has authored six local and international conference abstracts and one peer review journal publication.

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Determination of antioxidant, antibacterial, anti-inflammatory and anti-tyrosinase activities of peel, pulp and seed kernel of selected mango varieties in Sri Lanka

Ms. Anoosheya Kuganesan
College of Chemical Sciences, Institute of Chemistry Ceylon

Introduction

Mango (M*angifera indica L.*) is the king of fruits due to its flavor and health promoting activity. It is reported that mango is produced commercially in more than 87 countries.[1] Asia is the main mango producer in the world with 76.9% of the total world production.[2] Mango is one of the most cultivated fruits in Sri Lanka and a considerable amount of foreign exchange is earned by exporting raw and processed mango products. The demand for mango products are due to their strong aroma, intense peel coloration, delicious taste and high nutritional value.[2] Presently in Sri Lanka, different mango varieties are cultivated in about 26,000 ha of the whole land area and the total mango production is around 96,500 tons per annum.[2] Fruits of these different varieties have their own characteristic flavors and tastes.

According to the data available in the Department of Agriculture, 10 types of mango varieties are commonly grown in Sri Lanka, excluding the hybrid mango varieties. Among those varieties, Karuthakolumban, Willard, Vellaicolomban, Ambalavi

and Malwana mangoes are endemic to Sri Lanka. Mango fruits are processed for various products such as puree, nectar, pickles, ice-cream and canned slices in the food industry. Further mango fruits are used for development of cosmetic products such as face wash and cream in Sri Lanka.

Unedible peel and seeds are the major wastage generated during the food item manufacturing process. Currently unedible peel and seeds are not used in development of value added products and are discarded as a waste. A thorough literature survey indicated that peel and seed kernel of mango varieties available in Sri Lanka are underestimated. Extracts of peel, seeds and pulp can be used to develop value added products in food and pharmaceutical industries. Therefore the objectives of the present study was to evaluate antioxidant, antimicrobial, anti-tyrosinase and anti-inflammatory properties of peel, seed kernel and pulp of selected commonly available mango varieties endemic to Sri Lankan.

Material and Methodology

In the present study, the second batch of three mango cultivars, Willard, Karuthacolomban and Vellaicolomban were collected from Jaffna district during April-July (main mango season), 2015. Mango fruits were harvested at maturity stage and kept for two to three days to further ripen at room temperature. Peels and seeds were removed from ripe fruits. Pulp was cut into small cubes. Fresh peels, seed kernel and cube pulps were extracted into ethyl acetate to obtain secondary metabolites.

Ethyl acetate extract of pulp, peel and seed kernel of the three mango varieties were studied for *in vitro* antioxidant activities using different assays; DPPH radical scavenging assay[3], Ferric ion reducing power assay[4] (FRAP) and ABTS radical scavenging assay[5] ($ABTS^{\cdot+}$). Anti-inflammatrory activities of extracts were evaluated by Human red blood cell (HRBC) membrane stabilization method[6] and anti-tyrosinase actives of extracts were evaluated using mushroom tyrosinase enzyme[7]. Further, antibacterial activity of the extracts was tested against three pathogenic bacteria; *Escherichia coli* [ATCC 25922], *Staphylococcus aureus* [ATCC 25923] and *Bacillus subtilis* [MTCC 121] using agar-well diffusion method.

Results and Discussion

Evaluation of antioxidant activity of mango peel, pulp and seed kernel of mango varieties

DPPH radical scavenging activity: DPPH radical scavenging model is a widely used common method to evaluate antioxidant activity. This assay is based on hydrogen donating ability or radical scavenging ability of extract in alcoholic medium and it yields color change from purple to yellow.[8]

As shown in Table 1 excluding pulp extracts of Karuthacolomban and Vellaicolamban, all other seven extracts showed significantly ($p > 0.05$) higher activity than that of the standard, BHT (32.26±2.41 µg/mL). Karuthacolomban seed kernel gave the lowest IC_{50} value (7.73±0.26 µg/mL) indicating the highest radical scavenging activity among the test extracts. A considerably lower DPPH radical scavenging activity was observed for the pulp of the three mango varieties ($p > 0.05$) than that of the peel and the seed kernels.

ABTS antioxidant assay: ABTS assay based on electron transfer ability of the test sample with long life and reactive radical anion 2,2-azinobis(3-ethylbenzothiazoline-6-sulfonic acid). IC_{50} value obtained for Willard and Karuthacolomban peels were 186.68±13.63 µg/mL and 186.07±11.36 µg/mL, respectively (Table 1). These results suggest that there are no significant different between ABTS radical cation scavenging between Willard peel and Karuthacolomban peel ($p>0.05$). The $ABTS^{\cdot+}$ assay indicates that seed kernel of Karuthacolomban (46.22±1.82 µg/mL) showed significantly high radical scavenging activity, compared with the positive control Trolax that exhibit IC_{50} value of 136.92±3.29 µg/mL ($p \leq 0.05$).

FRAP assay: Ferric Reducing Power assay (FRAP) was used to measure the direct electron donating ability of extracts.[9] The result is visualized by measuring the absorbance at 700 nm, of the blue–green color complex formed. The peel extracts and seed extracts from the three mango varieties showed significantly different ($p > 0.05$) IC_{50} values of ferric reducing ability, ranging from 24 µg/mL to 88 µg/mL and 23 µg/mL to 52 µg/mL, respectively (Table 1). The FRAP assay indicated that seed kernel of Karuthacolomban (23.30±1.00 µg/mL) possess a significantly higher ferric reducing ability than the standard, L-Ascorbic acid (51.83±0.94 µg/mL) ($p < 0.05$).

Determination of anti-inflammatory activity using Human Red Blood Cell (HRBC) Membrane stabilization assay

Aspirin, anti-inflammatory drug was used as the positive standard to compare the anti-inflammatory properties of mango peel, pulp and seed kernel extracts.The extract obtained from peel of Karuthacolomban showed the highest anti-inflammatory activity (151.08 ±3.57 µg/mL) when compared with other test samples and the lowest activity was observed in the extract of Willard pulp (Table 1). The peel extracts from the three mango varieties showed significantly different values of inhibition of hemolysis, ranging from (IC_{50}) 151 µg/mL to 197 µg/mL (Table 2). Except Willard pulp all eight tested extracts showed significantly ($p > 0.05$) higher anti-inflammatory activity than that of the standard, aspirin (481.39 ± 8.11 µg/mL).

Anti-bacterial assay using agar well diffusion method

Evaluation of antibacterial assay was carried out comparative to the standard drug Azithromycin. DMSO was used to dissolve all plant extracts. Ethyl acetate extracts of pulp, peel and seed kernel of three mango varieties were tested for antibacterial activity using agar well diffusion method at 10 mg/mL against selected three bacteria strains. Seed kernel extracts of Karuthacolomban, Willard and Vellaicolomban showed the antibacterial activity against *S. aureus* and *B. subtilis.* None of the peel and pulp extracts inhibited the growth of *E. coli*, *S. aureus* and *B. subtilis.*

Determination of anti-tyrosinase activity using tyrosinase enzyme

Melanin is essential for protecting human skin against radiation, but formation of abnormal melanin course the pigmentation disorders.[10] Tyrosinase is a key enzyme that catalyzes melanin synthesis. Kojic acid, was used as the positive standard to compare the anti-tyrosinase properties of mango peel, pulp and seed kernel extracts. The results obtained in the present study indicate that all three pulp extracts did not show anti-tyrosinase activity in 100 µg/mL-2000µg/mL range (Figure 1) compared with the positive standard kojic acid that had the highest anti-tyrosinase activity. A moderately lower anti-tyrosinase activity was observed for peel extracts of all three mango varieties (Figure 2).

Figure 3 shows the anti-tyrosinase activity of mango seed kernel of the three selected mango varieties. The results revealed that among the seed kernel, Vellaicolomban seed kernel has higher activity and Willard seed kernel has lower activity compared with the positive standard.

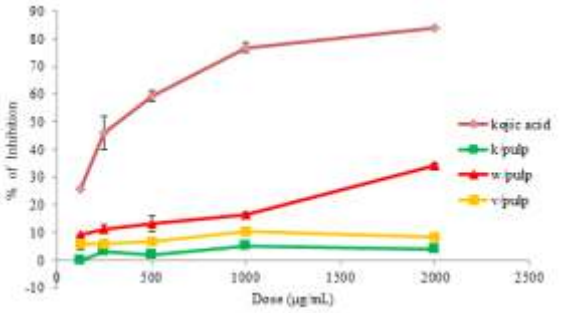

Figure 1: Comparison of inhibition activity of pulp extracts and positive standard Kojic acid anti-tyrosinase assay. Note: Each data point represents the mean of 3 replicates. K-Karuthacolomban, V-Vellaicolomban and W-Willard

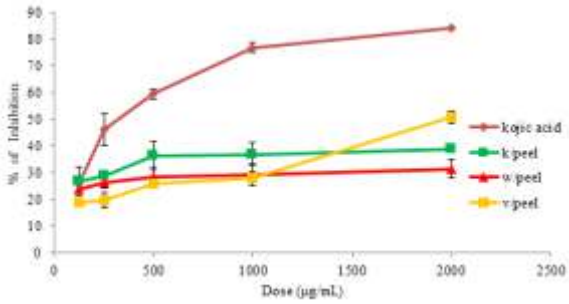

Figure 2: Comparison of inhibition activity of peel extracts and positive standard Kojic acid anti-tyrosinase assay. Note: Each data point represents the mean of 3 replicates. K-Karuthacolomban, V-Vellaicolomban and W-Willard

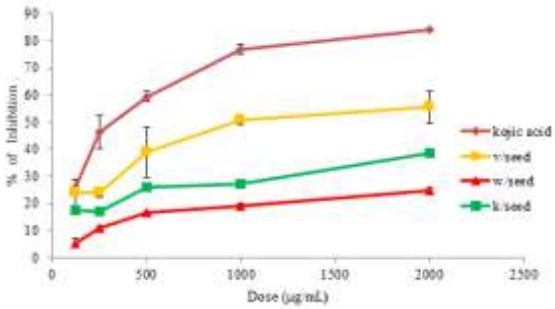

Figure 3: Comparison of inhibition activity of seed kernel extracts and standard Kojicacidanti-tyrosinase assay. Note: Each data point represents the mean of 3 replicates. K-Karuthacolomban, V-Vellaicolomban and W-Willard

Table 1: The IC $_{50}$ results obtained from bio assay for mango peel, pulp and seed kernel of Willard, Vellaicolomban and Karuthacolomban.

[illegible]		[illegible] IC$_{50}$ (µg/ mL)			[illegible] inflammatory IC$_{50}$ (µg/ mL)
		[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]^{a}	[illegible]^{a}	[illegible]^{a}	[illegible]^{a}
[illegible]	[illegible]	[illegible]^{b,d}	[illegible]^{b}	[illegible]^{b}	[illegible]^{b}
	[illegible]	[illegible]^{b,a,c}	[illegible]^{a}	[illegible]^{c}	[illegible]^{c}
	[illegible]	[illegible]^{e}	[illegible]^{d}	[illegible]^{d}	[illegible]^{d}
[illegible]	[illegible]	[illegible]	[illegible]^{e}	[illegible]^{e}	[illegible]
	[illegible]	[illegible]^{f}	[illegible]^{d}	[illegible]^{f}	[illegible]^{e}
	[illegible]	[illegible]^{d}	[illegible]^{f}	[illegible]^{g}	[illegible]^{f}
[illegible] kernel	[illegible]	[illegible]^{g}	[illegible]^{g}	[illegible]^{h}	[illegible]^{f}
	[illegible]	[illegible]^{h}	[illegible]^{h}	[illegible]^{a}	[illegible]^{g}
	[illegible]	[illegible]^{i}	[illegible]^{b}	[illegible]^{g,h,i}	[illegible]
[illegible]	[illegible]-Ascorbic acid	[illegible]^{c}	[illegible]	[illegible]^{g,i}	[illegible]
	[illegible]	[illegible]^{h}	[illegible]	[illegible]^{g,h,i}	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]^{h}

All data are presented as mean± SD of the three replicates. Mean followed by different letter in the same column differs significantly (p≤*0.05*).

Conclusions

In summary, investigation of antioxidant, antibacterial, anti-inflammatory and anti-tyrosinase activities of peel, pulp and seed kernel of three mango varieties demonstrated that the secondary metabolites content varies with the variety. Ethyl acetate extracts of the peel and the seed kernel of the three mango varieties contain more polyphenols than that of the pulp, and exhibited good antioxidant activity. In addition, peel and seeds extracts of the three mango varieties possessed good anti-inflammatory activity. Hence it ca be concluded that extracts of the seed kernel and the peel of Willard, Karuthacolomban and Vellaicolomban can be developed as ingredients of potential value added product.

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Theme Seminar on

Role of Chemists for a Better Tomorrow

Date : 15th June 2017 **Venue** : Plastic & Rubber Institute, Rajagiriya

Keynote Address

Exploiting Mineral Resources for Economic Prosperity

Professor Oliver A Ileperuma

Emeritus Professor, University of Peradeniya

Sri Lanka has an abundance of good quality mineral deposits which have not been effectively utilised for the economic development of the country. While some have not been exploited to their full potential, others are sold at a pittance to overseas buyers. Exploitation of mineral resources without the concomitant development of a chemical industry is meaningless; neither is possible without the other. At the present time we do not have a single chemical industry in Sri Lanka going by its true definition. For mineral development, it is essential that we have access to at least an acid and a base which are locally manufactured.

Salt based chemical industry

The per capita salt consumption is considered as an index of its industrial development and a greater part of salt produced is used for the chemical industry. The corresponding per capita values for USA and Sri Lanka are 158 kg and 7 kg, respectively which indicate that our industrial development is exceedingly low. During the 1970's we had the Paranthan Chemical corporation which manufactured sodium hydroxide primarily for the soap industry. Its by-products chlorine and hydrogen could have been used to manufacture hydrochloric acid with many potential applications. Although hydrochloric acid was manufactured for a brief period, it had to be abandoned due to lack of demand. Salt based chemical industry, if properly implemented would have immense economic benefits. What is required is an integrated approach where other industries can be developed using the byproducts of the Paranthan factory. Hydrochloric acid could have been easily employed as a pickling agent for the galvanisation industry for which we import acid. What is needed is an integrated approach for the development of our chemical industry. Chlorine produced at Paranthan was used to purify water in municipality water purification schemes. In addition the paper industry requires both sodium hydroxide and chlorine. Chlorine from sodium hydroxide plants may be used to manufacture polyvinyl chloride (PVC) where the vinyl chloride is prepared from carbide acetylene. We have not fully utilised the economic potential of the bitterns in the salterns of Sri Lanka. Production of 1 ton of salt produces 1 ton of bitterns and if a sodium carbonate plant is available, its waste containing calcium chloride can be added to bitterns to yield gypsum. Gypsum can also be separated during sea water evaporation in salterns which can be employed in the cement industry.

Production of phosphate fertilisers

Eppawela rock phosphate is a valuable deposit found in Sri Lanka which is used only to a limited extent for supplying plantation crops as powdered rock form. In the mean time we continue to export more soluble phosphate fertilisers for use in paddy and vegetable cultivation. If we produce sulphuric acid then it is possible to produce single superphosphate (SSP) from apatite which can then be used to supply all our phosphate fertiliser requirements. This involves simple mixing of the powdered rock with sulphuric acid which produces no effluents and uses simple technology. Research has been done on this process and agricultural experts have found it as a viable substitute to the imported triple superphosphate (TSP) and field trials have found this suitable for all agricultural areas of the country. Furthermore, SSP contains sulphur (in the form of calcium sulphate) which is an additional nutrient required by plants while TSP has no sulphur in its composition. However, there is still no sign of such a development while we spend valuable foreign exchange to import phosphate fertilisers.

Exploiting the economic potential of mineral sands

Sri Lanka has an abundance of mineral sands and the main deposit is found at Pulmoddai consisting of ilmenite, rutile and zircon and a deposit at Beruwela consisting of monazite which is an insoluble rare earth phosphates along with a variable percentage of thoria. It is possible to develop this highly profitable industries based on these minerals if a supporting chemical

industry is established. At the moment we export mineral sands such as rutile and ilmenite at extremely cheap prices to overseas companies. It is possible to make titanium dioxide pigment if sulphuric acid is locally manufactured. Similarly if the Paranthan plant comes into operation, then its excess chlorine can be utilised to make titanium metal *via* the chloride reduction routFurther we have an abundance of a mineral sand deposit containing monazite and rare earths at Beruwela. Rare earths have a ready market in the electronic industry if they can be separated. Monazite also contains the radioactive element thorium which is used in the production of nuclear fuels. At one time there was a small processing plant at Katukurunda for processing monazite and to separate the rare earth phosphates found in this type of sand. Thorium is also present in the mineral thorianite, an extremely pure form of thorium oxide which was exported from Sri Lanka during early 1900's from mines at Nelluwa in the Galle district. Marie Curie used thorianite from Sri Lanka (Ceylon) in most of her research leading to the discovery of new elements radon, polonium and the radioactive disintegration law.

Quartz

High quality quartz is found in many locations in the country and these are currently exported in the raw form without any value addition. Silicon production from quartz is not practical since it is technologically very complex and the electricity requirements are very high. However, there are many other smaller industries which can be started with quartz as the raw material such as water glass (sodium silicate), quartz lenses and other quartz glass items which involves simple melting and reforming of quartz.

Graphite

There are a number of other minerals where value addition can be carried out in Sri Lanka. The best quality graphite in the world have always come from Sri Lanka and only about 5% of the total graphite mined is used in Sri Lanka. Further, the Ceylon Ceramics corporation at one time had a small crucible factory at Hal oya near Peradeniya where graphite was used to make crucibles for the foundry industry. This industry too died as a result of the post 1977 economic liberalisation policy. All graphite we mine now is exported and we purchase the finished products of graphite such as carbon brushes for motors and electrodes for dry batteries from abroad at exorbitant prices. Graphite can be used to produce carbon nanotubes with a growing demand. Recent research carried out in Sri Lanka show that graphene prepared from our graphite has super-capacitor properties and this may find its way to more efficient batteries for mobile devices and even electric cars.

Iron industry

Archaeological evidence points out to a well organised steel industry in Sri Lanka dating as far back as 1200 A.D. There is evidence for a large steel manufacturing facility in the southern slopes of the Samanalawewa area where wind tunnels were used to create the high temperatures required for the iron making process. This process has been repeated recently by a British Archaeologist where good quality steel was obtained. Recently a good quality magnetite ore has been discovered off Buttala by geologists of the University of Peradeniya. This ore contains about 60 –70% iron in quite pure form and found at the surface and far superior in quality to already recorded iron ore deposits found elsewhere in the country. There is also an iron pyrites ore deposit at Seruvila which contains about 1% copper and this is a unique deposit since it is the only ore containing both copper and sulphur found in Sri Lanka. Red soils at Ussangoda, Hambantota is rich in nickel which can be commercially exploited. Simple leaching with sulphuric acid leaches nickel as nickel sulphate which can be purified and used for the nickel plating industry.

Other minerals of economic value

There are other minerals which can be used to make some of the chemicals we currently import. For example, the drug industry uses magnesium carbonate and calcium carbonate as bulking components of drugs. We have a calcite deposit at Balangoda and precipitated calcium carbonate required by many industries can be made starting with this deposit of calcite. Sri Lanka imports approximately 60,000 tons of precipitated calcium carbonate for the toothpaste industry.

Conclusion

Mineral resources in Sri Lanka can be used for economic prosperity of the nation provided that a supporting chemical industry can be developed. We had a rudimentary chemical industry in the 1970's at Paranthan but no steps have been taken to commence chemical industries in Sri Lanka. What is urgently required is a comprehensive and an integrated approach policy to commence the manufacture of basic chemicals in Sri Lanka so that our mineral resources can be utilised to reap economic benefits to Sri Lanka.

Effect of nutrients on body chemistry in the management of CKD- A challenge to slow the progression

N M S Hettigedera, *MSc, C.Chem., MRACI (Australia) F I Chem C (SL),FRSH (UK) R.Nutri. R.D*
Superintendent of Police, Nutritionist & Dietician, Police Hospital

Chronic Kidney Disease (CKD) is a growing public health problem associated with significant health issues in the world as well as in Sri Lanka. Only a small proportion of these patients in stages I-V reaches the End–Stage Renal Disease (ESRD) and the majority at ESRD succumb to death before the renal replacement therapy. One reason may be due to the non availability of proper medical nutrition therapy. It is hypothesized that, it is essential to have a proper evidence-based renal diet as well as regular monitoring process to manage the disease condition without any progress of diseases and other health issues. This hypothesis is based on the research which has been carried out at a preliminary level.

Provision of better nutrition is beneficial in reduction of workload on the kidney as well as provision of improved overall health. In this regard, the renal dietitian/nutritionist plays a vital role. The dietetic knowledge of dietitian is used within the process of Medical Nutrition Therapy (MNT). To apply the MNT for the patient it is necessary to study the patients' condition with adhering to the Nutrition Care Plan (NCP) which consists of nutrition assessment, nutrition diagnosis, nutrition intervention, monitoring and evaluation.

Initially the patient is required to be assessed by the dietitian using anthropometric, biochemical and clinical parameters available before the dietary recommendations. It is vital to recognize the requirements of the patients and address the problems related to the disease condition. Nutrition diagnosis is based on the above step.

Patients are instructed under the nutrition counselling process to follow the nutrition intervention. In this step, combination of local and international guidelines are utilized in prescribing renal diets. Renal diets are planned according to the requirement of the patients' body chemistry and hence the diet is individual based. Requirement of macro and micro nutrients are calculated based on biochemical data of patients.

Carbohydrates, proteins and lipids provided from the diet, influence the body chemistry and the functions of the kidney. Further micro nutrients such as potassium, phosphorous, sodium and calcium have a great effect on the kidney. Thus, it is necessary to utilize scientific knowledge related to food, nutrition and dietetics.

It is essential to control the blood pressure, reduce the albuminuria, manage diabetes, and manage the lipid profile within the body in order to slow the progression. Dietary intervention is necessary to play a role in slowing the progression of CKD. Further, it is necessary to address the complications associated with CKD; malnutrition, metabolic acidosis, hyperkalemia, bone mineral diseases are associated with CKD and anemia. All these conditions are taken in to consideration by the dietitian in prescribing a renal diet for the patient.

Monitoring and evaluation is also play an important role in Nutrition Care Plan (NCP) as it necessary to assure that the biochemical environment of the patient is under control along with the medications and the medical nutrition therapy. Thus, it is essential to check the biochemical reports of the patients on a periodical manner.

A research is being conducted at the Sri Lanka Police Hospital Colombo 05, on "The effect of dietary, lifestyle modification and regular monitoring on patients with Chronic Kidney Disease; by evaluating of e GFR, Serum creatinine, and lipid levels". The Objectives of the research is to study the effect of lifestyle modification and regular monitoring on clinical outcome of CKD and to study the impact of correct nutritional assessment and medical nutrition therapy of the pre-dialysis CKD patients.

Methodology adopted is as follows. CKD patients referred to the medical clinic are examined by a physician. The patients are referred to the dietitian for MNT as routine practice in medical clinic/OPD of the hospital. A register is maintained and the patients are monitored at regular intervals depending on the patients' condition. Dietary modification are conducted based on the available biochemical data and the data are recorded in a Monitoring Chart at each and every visit as a systematic task.

Both male and female pre -dialysis CKD patients who are in stage I –V are included. Patients who are undergoing dialysis and who are over 80 years are excluded. Eligible patients are required to submit the letter of consent.

Data collection is carried out as an initial step

through recording personal details, nutrition history, diet history, biochemical reports, anthropometric data as well as social and cultural back ground of the subjects. Data are collected through an interviewer administered questionnaire and a medication profile of the patient. Dietary advice and nutrition counseling are provided by a qualified registered dietitian. Patients' compliance is reassessed monthly during the study period.

Results show that there is a significant decrease of serum creatinine level in 67.8% of the sample (Sample size is 35: n= 35). There is a significant increment of e GFR level in 60 of the sample. The LDL level of 96 % of the sample are within the normal range. The HDL level of 92.8% of sample are within the normal range.

It is concluded that there is a significant effect of dietary intervention on slowing the progression of CKD as well as the management of complications related to CKD. The paper presented is based on the above results.

Note: The above research project is supervised by Professor P. A. Paranagama, Senior Professor in Chemistry, Department of Chemistry, University of Kelaniya and Dr. U. Weragama, Consultant Physician, Sri Lanka Police Hospital, Narahenpita.

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Theme Seminar on Role of Chemists for a Better Tomorrow

Date : 15th June 2017 **Venue** : Plastic & Rubber Institute, Rajagiriya

Professor Oliver Illeperuma

Professor Nilwala Kottegoda

Professor Nilanthi Bandara

Mrs. Sakunthala Tennakoon

Dr. Sayuru Samarasundera

Mr. N M S Hettigedara

Dr Meththika Vithanage

Dr. Renuka Silva

Section of participants

Section of participants

Chemistry Olympiad Sri Lanka 2017

The International Chemistry Olympiad (IChO) is a competition organized for secondary school students of all levels from all over the globe with the objective of promoting their creativity and cognitive skills in solving chemistry problems. The IChO steering committee has officially accepted the Institute of Chemistry Ceylon (IChemC) as the official organizer to conduct the National Chemistry Olympiad competition in Sri Lanka. In 2016, the governing Council of the IChemC formed a committee comprising of academics attached to universities and institutes to organize and conduct the National Chemistry Olympiad Competition in Sri Lanka, which is named as "**Chemistry Olympiad Sri Lanka**".

National Chemistry Olympiad Committee

- Dr Chinthaka Ratnaweera (Chairman) – Senior Lecturer, Institute of Chemistry Ceylon
- Dr H. Ireshika De Silva (Secretary) – Senior Lecturer, University of Colombo
- Prof Janitha Liyanage – Head, Department of Chemistry,, University of Kelaniya
- Prof Priyani Paranagama – Dean, College of Chemical Sciences, Institute of Chemistry Ceylon
- Prof Sudantha Liyanage – Dean, Faculty of Science, University of Sri Jayawardhanapura
- Dr Poshitha Premarathne – The President of Institute of Chemistry Ceylon and the Past Chairman of The Royal Society of Chemistry- Sri Lanka section
- Dr Chandani Udawatta – Senior Lecturer, College of Chemical Sciences, Institute of Chemistry Ceylon
- Dr Sameera Gunathilaka – Senior Lecturer, College of Chemical Sciences, Institute of Chemistry Ceylon
- Dr Gobika Thiripuranathar – Senior Lecturer, College of Chemical Sciences, Institute of Chemistry Ceylon
- Dr Punya Keerthi – Secretary, Institute of Chemistry Ceylon
- Dr Piyal Ariyananda – Scientist, MAS Holdings

The first Chemistry Olympiad Sri Lanka (COSL) was successfully conducted on 15th and 16th May 2017 at Adamantane House, Institute of Chemistry Ceylon, Rajagiriya. The finalists for the COSL were selected from the All Island Inter-School Chemistry Quiz conducted by the Institute jointly with the Ministry of Education, Sri Lanka in January 2017.

Prior to the COSL competition, one-and-a-half-day training camp including laboratory practical sessions was conducted. Twenty four finalists representing most of the provinces including Northern and Eastern provinces, and the teachers participated at this training camp. The final competition consisted of a one-and-a-half-hour theory (written) paper and a one-and-a-half-hour practical examination.

Udara Nirmani Samaranayake from Mahamaya Girls College, Kandy won the first place of COSL 2017, and S Priyanwadha Mudalige from Maliyadewa Balika Vidyalaya, Kurunegala and A A G H Abeysinghe from Mahamaya Girls College, Kandy secured the second and the third places, respectively.

Udara Nirmani | Priyanwadha Mudalige | A A G H Abeysinghe

Six Merit awards were awarded to P I U Wijewardana (Maliyadewa Balika Vidyalaya, Kurunegala), Saveen Weeranayaka (Richmond College, Galle), Yasod Sandeepa Ginige (Richmond College, Galle), P M S T Pathinisekara (Mahamaya Girls School Kandy), Tharusha Lakshini (Anula Vidyalaya Nugegoda) and Hasitha Geeth Gunasinghe (Joesph Vaz Vidyalaya, Wennappuwa).

The Institute of Chemistry Ceylon is looking forward to participate at the IChO to be held in 2018 and 2019 representing Sri Lanka as observers with the aim of sending a team for IChO in 2020. Institute seeks sponsorships for both National and International Chemistry Olympiad competitions and anticipates the generous support from Members to make this a reality.

Chemistry Olympiad Sri Lanka 2017

Part of the Chemistry Olympiad Committee members and the Finalists 2017

P P G L Siriwardene Memorial Lecture 2017

Emeritus Professor Ajit M. Abeysekera

on

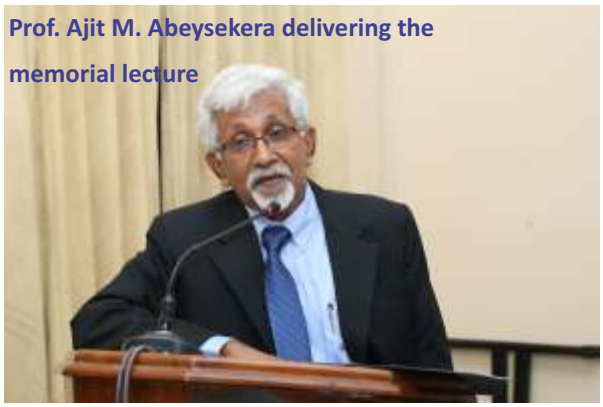
"From rice hull to fine chemicals: An excursion into chemurgy"

Venue: P P G L Siriwardene Auditorium, Adamantane House, Rajagiriya Date: 21st April 2017

Welcome Address by Mr. M R M Haniffa

Introduction of Orator by Prof. S P Deraniyagala

Prof. Ajit M. Abeysekera delivering the memorial lecture



Section of participants

Section of participants

Vote of Thanks by Lilantha Siriwardene

From rice hull to fine chemicals; a brief excursion in to chemurgy

Professor A M Abeysekera
Professor Emeritus, Universiy of Sri Jayewardenepura
Consultant, Link Natural Products

Chemurgy is a branch of applied chemistry concerned with the industrial use of biomass for fuel and chemicals. The birth of the chemurgy movement can be traced to the 1920's in the United States of America. The early chemurgists were ardent nationalists who believed that America should be self-sufficient and not have to depend on imports. One of the leaders of the chemurgy movement William Hale stated in 1926 that "Farming must become a chemical industry". He was supported by Henry Ford and Thomas Edison and Ford in 1929 created the "Edison Institute" for developing new industrial uses for farm crops. Industrial alcohol mixed with petrol was used widely as an automobile fuel in the 1930's. In 1941, Ford exhibited a "Soya bean car" where the car panels were all made by plastics made from soya bean. Ethanol was also a starting material for the synthesis of butadiene rubber. However, the advent of cheap petroleum dampened the chemurgy movement, and by 1945, petroleum byproducts were the feedstocks for both ethanol and butadiene. The oil crisis in the 1970's rekindled the interest in chemurgy worldwide. The increased awareness of renewable and non-renewable resources and the current emphasis on sustainable development has once again brought chemurgy to the forefront in applied chemistry.

Our excursion into chemurgy started with the extraction of furfural from rice hull. Sri Lanka produces over 4 Mn metric tons of Rice which generates about 1 Mn metric tons of hull (husk) whose composition is approximately 25% silica, 25% lignin, 15% pentosans and 35% cellulose. Heating the hull with aqueous acid hydrolyses the pentosans to pentoses which then dehydrate to furfural in a total yield of around 10%. Furfural is an important industrial chemical used as a selective solvent to extract unsaturated compounds from lubricating and vegetable oils. An important bulk derivative of furfural is furfuryl alcohol which used to prepare polymers with very high thermal and chemical resistance.

As Sri Lanka did not have its own source of petrochemicals as feedstock for industry, we decided to focus our attention on the development of syntheses for fine chemicals from furfural which could have applications in the perfumery and drug industry. As shown in Figure 1, the condensation of furfural with methyl ketones yields furfurylidene ketones, which can be cleaved hydrolytically to give 4,7-dioxocarboxylic acids.

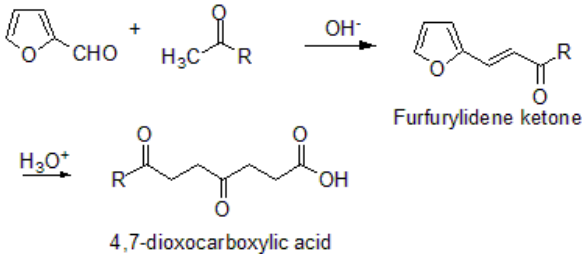


Figure 1. Synthesis of 4,7-dioxocarboxylic acids

These dioxocarboxylic acids are interesting multifunctional compounds. It had been reported in the literature that they could be converted to ɣ-lactones using the Clemmenson reduction, and to cyclopentenones by base catalysed cyclisation (Figure 2). The cyclopentenones could be elaborated into odorous compounds such as *Z*-jasmone. Long chain ɣ-lactones are known as flavor and fragrance compounds (natural and synthetic), as well as having pheromone and anti-feedant activity.

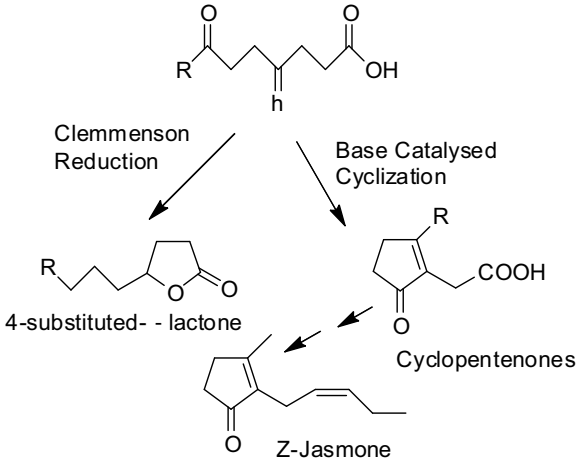
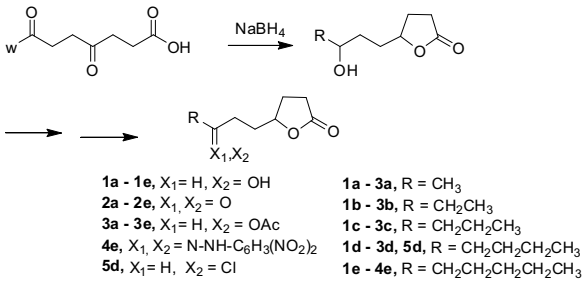


Figure 2. Conversion of 4,7-dioxocarboxylic acids to odorous compounds

We were able to synthesize a range of 7-functionalised ɣ-lactones by reducing the corresponding 4,7-dioxoacids with sodium borohydride to obtain 7-hydroxy ɣ-lactones and then

manipulating the hydroxyl group to obtain different functionalities (Figure 3). The biological activities of these compounds have yet to be evaluated. However, preliminary studies indicate that the 7-hydroxy and 7-acetoxy lactones have insect attractant activity, and that the dehydration of the 7-hydroxy lactones produce pleasantly odorous compounds.



1a - 1e, X_1= H, X_2 = OH
2a - 2e, X_1, X_2 = O
3a - 3e, X_1= H, X_2 = OAc
4e, X_1, X_2 = N-NH-$C_6H_3(NO_2)_2$
5d, X_1= H, X_2 = Cl

1a - 3a, R = CH_3
1b - 3b, R = CH_2CH_3
1c - 3c, R = $CH_2CH_2CH_3$
1d - 3d, 5d, R = $CH_2CH_2CH_2CH_3$
1e - 4e, R = $CH_2CH_2CH_2CH_2CH_3$

Figure 3. New 7-functionalized ɣ-lactones synthesized from 4,7-dioxocarboxylic acids

Two byroads on the path to ɣ-lactones led us to examine the regioselectivity of the condensation of methyl ketones with furfural and the anomalous solid state IR spectrum of 4,7-dioxoacids which gave a single peak at 1685 cm^{-1} for the three different carbonyl groups in the molecule. Thus, we were able to show that initial condensation of a methyl ketone with furfural occurred on both the methyl and methylene carbons, and that the dehydration of the initially formed β-hydroxy ketone to the furfurylidene ketone was hindered on the methylene side due to conformational effects (Figure 4). The x-ray crystal structure of 4,7-dioxononanoic acid (Figure 5), showed that the carbonyl groups were all aligned linearly bringing about dipole-dipole interactions which lowered the frequency. Thus the normal 'dimeric' structure for carboxylic acids in the solid state does not occur in these compounds. Two peaks at 1705 and 1715 cm^{-1} were observed when the compound was dissolved in carbon tetrachloride.

Our second exploratory pathway was to synthesise heterocyclic compounds as potential drug molecules. As it was known that pyridazine was a privileged structure in medicinal chemistry, we attempted to react 4,7-dioxocarboxylic acids with hydrazine, a dinitrogen nucleophile, to synthesise pyridazinyl propionic acids as potential COX inhibitors. While a small yield of the pyridazinyl propionic acid was formed, the major products were rather unusual bicyclic compounds (Figure 6).

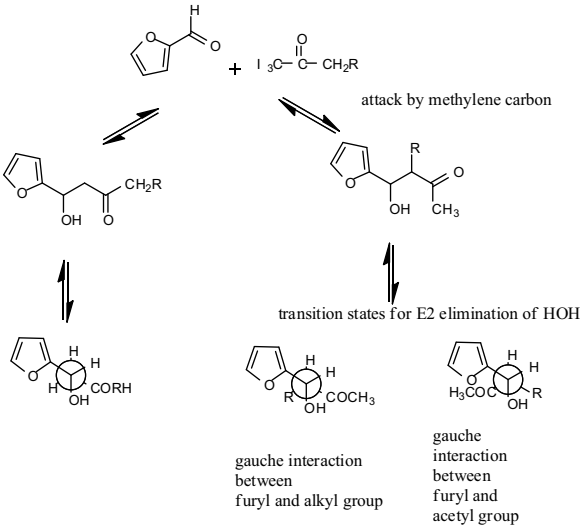


Figure 4. Conformational effects determining regioselectivity in the condensation of methyl ketones with furfural.

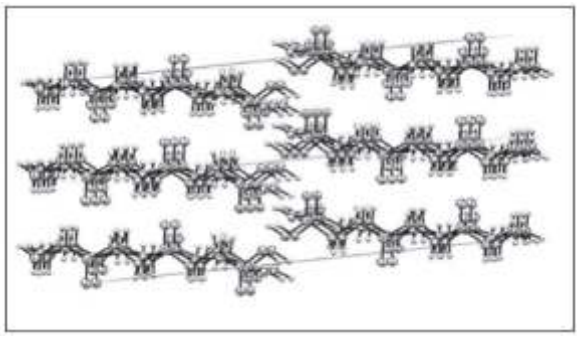


Figure 5. Crystal packing of 4,7-dioxononanoic acid showing linear arrays of carbonyl groups.

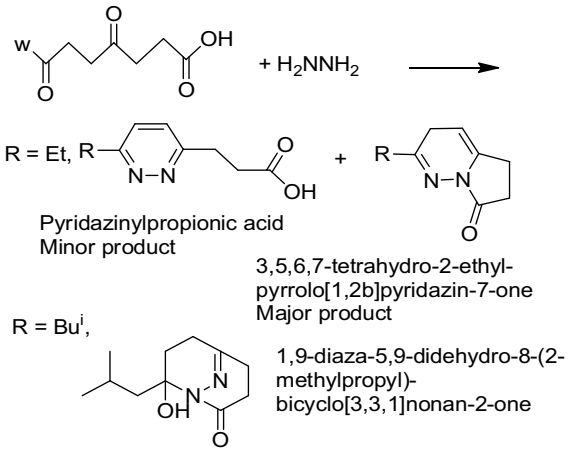


Figure 6. Synthesis of heterocyclic compounds from 4,7-dioxocarboxylic acids with hydrazine.

Thus, 4,7-dioxononanoic acid gave a pyrrolopyridazine as the major product while 9-methyl-4,7-dioxodecanoic acid gave a diazabicyclo[3,3,1]nonanone as the major product.

The pyrrolopyridazine ring system obtained is rare, with less than ten compounds reported with this ring structure, while the the diazanonanone is a new ring structure. Its structure was elucidated by detailed spectroscopic analysis and computational studies have confirmed that it is a stable structure.The formation of these products can be rationalized as taking place via a common hemiaminal intermediate, with steric effects determining the type of bicyclic product formed (Figure 7). Reaction of 4,7-dioxononanoic acid with hydroxyl amine gave an oxazine derivative, while reaction with phenylhydrazine gave a pyrrole derivative.

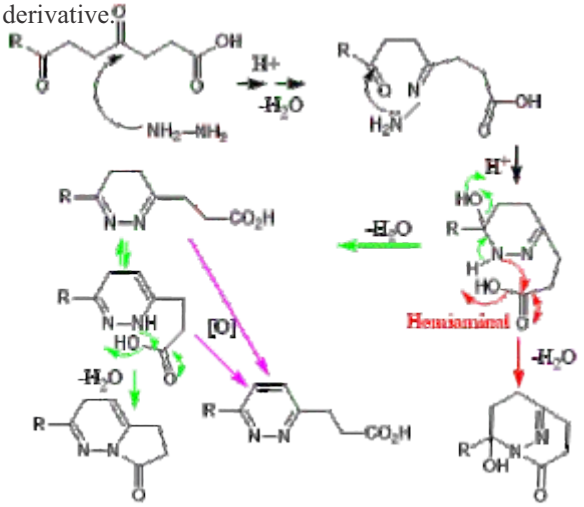


Figure 7. Proposed reaction pathways to heterocyclic compounds

Initial in *silico* screening of these molecules with various enzymes and receptors indicate that 3-(4-isobutyl-pyridazine-1-yl)propionic acid interacts with PTP1B, an enzyme target for the treatment of obesity and type II diabetes.

Our excursion into chemurgy has taken a long time, and we have still a long way to travel. However, from where we are now, we can see that there are many inviting and exciting vistas ahead of us. It is with a sense of reverence that I dedicate this work to the memory of a person who has made an immense contribution to chemical education and industrial/applied chemistry in Sri Lanka, Professor P.P.G.L. Siriwardene.

Graduate Chemists Welfare Fund

This fund has been established with effect from 1-1-2012. The principal benefits towards CCS Graduate Chemists would be,

I. To provide partial assistance towards international travel of those proceeding abroad for PG degrees (once a life time). Assistance for
   - Active Graduate Chemists : Rs. 60,000
   - Passive Graduate Chemists : Rs. 30,000

ii. To provide partial assistance towards registration fees in respect of IChemC /CCS events such as international Conferences.

iii. To provide assistance towards registration fees for IChemC /CCS training seminars etc.

iv. To provide partial assistance towards activities of the Alumni Association.

Note :Depending on the demand, Graduate Chemists who maintain positive contact and participate in IChemC/Alumni activities will get preference for the above mentioned assistance scheme.

Guest Article

WWW: Wealth, Waste to Water

Dr. Meththika Vithanage

Senior Lecturer, Office of the Dean, Faculty of Applied Sciences, University of Sri Jayewardenepura, Nugegoda
Associate Research Professor, School of Civil Engineering and Surveying, Faculty of Health, Engineering and Sciences, University of Southern Queensland, West Street, Toowoomba, Queensland, Australia

Rapid urbanization, rise in community living standards, less political will and poor planning negatively influenced the waste management practices in Sri Lanka where the wealth is finally ended up in open dump sites generating shocking signs to water quality. Water quality, a significant determinant of health and hence, causes significant social, health costs and economic inefficiencies, is inestimably influenced by the leachate that discharged directly from the open dumps in Sri Lanka without any treatment.

One of the biggest challenges of the 21st century is the municipal solid waste (MSW) management with environmentally accepted nature in many countries. However, when it comes to the developing region of the world, open dumping of waste is the most common method used to dispose municipal solid residues. Similar to the most South Asian courtiers, in Sri Lanka, the predominant practice of waste disposal is by means of open and controlled dumping. Sri Lanka well experienced the consequences of uncontrolled dumping municipal solid waste (MSW) on April, 2017 with the devastating dump slide burring hundreds of people within few seconds. Open dumping of waste with higher organic content further aggravates problems due to formation of large amount of concentrated leachate. The landfill leachate is one of the major sources for the presence of high concentrations of toxic metals, carcinogenic and mutagenic carbon compounds and nitrogenous compounds.[1-3] The characterization of the landfill leachate plays an important role when determining the treatment method. Landfill leachate in the humid tropics may show a clear difference from that of the temperate and arid regions.[2] In addition, most of the leachate characterization studies were found for developed countries and there are many limitations for the developing countries. Unfortunately, only a few studies were carried out to evaluate the pollution level of leachates in Sri Lankan dumpsites since most of the leachate directly flows to nearby water sources leading significant pollution to the environment.[4]

Wealth to waste: Waste load and composition

At present, average solid waste generation in Sri Lanka is 6,500-9,000 tonnes per day and recent studies showed that the rate of wealth to waste or the waste generation rate in most urban population in Sri Lanka is close to 1 kg/capita/day.[5] There is no weighting facility where the dumpsites are located and hence, no proper records on MSW generation and everything are based on the estimated data. It has been found that more than 60% of the MSW in Sri Lanka is organic matter, whereas paper, wood, plastic, metal and glass encounter for the rest 12, 10, 7, 4 and 3%, respectively.[6] In terms of waste composition, a database published by CEA in 2012 revealed that the Sri Lankan MSW mostly consists of short term 54.5% bio-degradable waste (i.e. food/kitchen Waste, animal and plant matter etc). Long term bio-degradable waste accounted for 5.9% whereas non-biodegradable waste amount was 10.5%. Further, metal waste, wooden waste, paper and cardboard waste, cloth/garment waste, construction waste and hazardous waste accounted for 1.8, 6.1, 3.7, 1.2, 2.8 and 0.4%, respectively.

Waste to water: Landfill leachate

The matrix of contaminants liquid that drains by landfill is termed leachate and mainly leachate forms as rainfall percolates through the surface of and into the refuse material of a landfill. Hence, direct relationship can be identified between precipitation or seasonal variation with leachate generation. In addition, the moisture content of waste is also significantly influenced to generate quantity of leachate. Landfill leachates from the MSW are variable and complex materials, reflecting the composition of solids deposited in the landfill. It is a common source of many contaminants, and MSW leachates often have high concentrations of heavy metals (such as Pb, Cd, Ni, Cr, Zn, Mn, Cu, Fe), dissolved organic carbon components (such as humic, fulvic and hydrophilic acids), inorganic ions (such as NO_3^-, NH_4^+, NO_2^-, PO_4^{3-}, SO_4^{3-}, Cl^-), persistent organics and xenobiotic organic compounds (such as halogenated hydrocarbons, aromatic hydrocarbons, phenols, benzene, chlorinated

aliphatics). However, leachate characteristics can differ between temperate and tropical countries because of climatic differences and chemical variation stemming from dissimilar consumer patterns.

The Gohagoda open dumpsite

The Gohagoda open dump site in Kandy, is receiving MSW from the world heritage city, Kandy since 1960's (Fig 1). Presently, ~130 tones/day of MSW including waste from slaughter houses, fish market, households and hospital waste are being directly dumped without any sorting or pretreatment. The leachate emission rate at the Gohagoda is estimated as 30,304 m^3/year.[7] The existing drainage channel streaming from the dump site and adjoining lands directly flows to the River Mahaweli, the largest and longest river in Sri Lanka, without being exposed to any treatment process which could lead to adverse environmental and health impacts since the water supply intake for the nearby urban area is just <400 m upstream where very minute flow rate of river water is present due to adjacent Polgolla reservoir (Fig 1).

Figure 1. Location of the Gohagoda MSW open dump site in Kandy, Sri Lanka

End point of leachate: Pollution to drinking water

Monitoring leachate from four sampling points of the leachate drainage channel was conducted monthly. GS1 and GS4 were located at starting and end point of the channel whereas GS2 and GS3 points were at the middle (Fig 1). The analytical results for many of the parameters like BOD_5, COD, pH, alkalinity, ammonium nitrogen *etc* demonstrate a remarkable similarity with leachate (i.e. methanogenic leachate) generated from old landfills in the world (Table 1).The BOD_5 and COD values, respectively exceed almost 50 times and 10 times the permissible levels for wastewater. At the same time, Gohagoda leachate is rich in Volatile Organic Compounds (VOCs) such as toluene, xylene and benzene which are carcinogenic and mutagenic to human cells. The reported concentrations of toluene, benzene and xylene are 19, 22 and 6.8 μg L^{-1}.[8] Furthermore, 8 VOCs were reported from the leachates in the dump where these are emitted to the atmosphere or else flow towards the river.[8]

Further, Table 1 reflects a comparison between observed data with tolerance limits for the discharge of industrial waste in to inland surface waters by the Central Environmental Authority (CEA), Sri Lanka. The demonstrated values for ammonium-N, phosphate, solids and some heavy metals concentrations including Ni, Cr, Pb were much higher exceeding country's permissible levels for waste water discharge. Even though, some parameters bellow to the recommended values, there is an extensive pollution occurring since the cumulative load discharge to the river annually.

Table 1: Comparison of the experimental results for landfill leachates in Gohagoda open dump site (GS 1 and GS4 locations) with methanogenic and acetogenic leachate characteristics in Robinson 2007 (Results in mg/L unless pH, conductivity mS/cm, * denotes for annual average value)

FŎĈĚĐÞÑŎPĈE	GŎOMŊŎÑMŎÑMÓOMĂÑĈĚÅ		ĖÑÑPŎŊÑŎÒÑ leachates	Ì ÑPOMŎŎŊÑŎÒÑ leachates	FĜĖ ŒMŎÑMŊÑ
	GĬ Ĉ	GĬ Ç			
ŐG	ĐBĈČ	ĐBĈĎ	DBD - 7	ĐBD - 8.5	Ď - 8.5
ĘÎ G5	ĈĆEĆ	DČĐ	ÇĆĆĆ - 30000	ÊDĆĆ - 1000	ĊĆ
FÎ G	ĈĊČÇĐ	ĈÇČD	ĈĆĆĆĆ - 50000	ČĆĆĆ - 6000	ČDĆ
İ SS	ĈĐĊĆ	ĈČĎ			50
ĖŎŎMŎŎÒÐŘ	ĐĐEĆ	ČDĐE	ČĆĆĆ - 10000	ĈĆĆĆĆ - 30000	
ĖÖÖŎŎŎM-nitrogen	ĈĈĈĊ	ĊĊĆ	ĐDĆ - 2000	ĈDĆĆ - 3000	DĆ
Í ÒÐÓMĂÑ-nitrogen	ĈČĐ	ĊČ	Ê1	Ê1	
ÎOĂČÉÓOMĂÑ	ĈĆĐ	DÇ	D - 20	ĈĆĆĆ - 3000	D
FOŎŎÖÒÐÖ	ĆBĈĊ	ĆBĆE	ÊĆBĈ - 0.1	ÊĆBĊ - 2	ĆBĈ
IÑMŇ	ĆBĈĐ	ĆBĈÇ	ÊĆBĈ - <0.5	ÊĆBĆD - 0.2	ĆBĈ
ĶŎŎŃ	ĈBĈD	ĆBĊ	D-20	ÊĆBĆĈ - 0.05	D
Í ÒŇĈÑÕ	ĆBĊĊ	ĆBĈĈ	ÊĆBĈ - <1	ÊĆBĆD - 0.1	ĆBĈ
FMŇÖÒÐÖ	ĆBÇĆ	ĆBĆĈ	ÊĆBĈ - <0.2	ÊĆBĆČ - 0.01	ĆBĈ

Risks on the public

Landfill leachate discharges to the river Mahaweli, is rich in dissolved organic compounds, can complex toxic heavy metals, allow those to flow and transport easily to water supply schemes. At the same time, the leachate may contain pharmaceuticals such as antibiotics, pesticides such as household pest management items as well as the clinical waste, may generate the environment for evolving pollutant resistant microorganisms. Similarly, leachates from open dumps may rich in persistent organic carbons. Chlorination is commonly used in the water treatment process in Sri Lanka. Dissolved organic carbon (DOC)

from landfill leachate may contributes the formation of various disinfection by-products (DBP) such as trihalomethane (THMs) and haloacetic acids (HAAs) during the disinfection process with chlorine. These carcinogenic compounds may impose a threat to the health of the general public. The context may become severe due to the disposal of hospital waste into the landfill and the leachate may pollute to an extremely dangerous level beyond redemption.

Concluding remarks

The physico-chemical composition of landfill leachate along with its temporal and spatial changes well illustrates the extent of pollution of the receiving water bodies and risks associated with the water use. It is an urgent need to implement leachate treatment facility to reduce the risk and the vulnerability of public health.

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RSC NEWS

THE ROYAL SOCIETY OF CHEMISTRY SRI LANKA SECTION

1. Membership

According to the records sent to us from the parent body, a breakdown of the membership is as follows:-

Category	Number
CChem, FRSC	09
FRSC	03
Chem, MRSC	07
MRSC	27
AMRSC	18
Affiliate /Under Graduate.	10
Total Membership as at July 2017	**74**

2. Committee of Management

The following were elected to the Committee at the 56th Annual General Meeting held in July 2017.

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Hony. Secretary - Dr W G Piyal Ariyananda
Hony. Treasurer - Dr. P Iyngaran

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Ms. Subodika Hemathilake

Co opted Members

Dr. M.K. Deeyamulla
Prof. W S Fernando
Mr. T M Kumara

3 Activities

3.1 Contributions to Activities of the Institute of Chemistry Ceylon
- (a) Full page advertisement of "Chemistry in Sri Lanka".
- (b) Contribution for the Interschool Chemistry Quiz
- (c) Award for the Best Performance at the Graduateship Examination in Chemistry Levels 3/4 Theory Examination

3.2 All - Island Inter School Chemistry Essay Competition.

3.3 Inter University Chemistry Essay Competition

3.4 Book donation programme

3.5 A/L Teacher training workshop

3.6 Advanced Level Chemistry Seminar

3.7 Industrial Visit for B.Sc. Special degree students, M.Sc. students and RSC Members

3.8 Collaboration with SLAAS E-2 workshop and seminars

3.9 Supporting Chemical Societies of Universities in Sri lanka

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