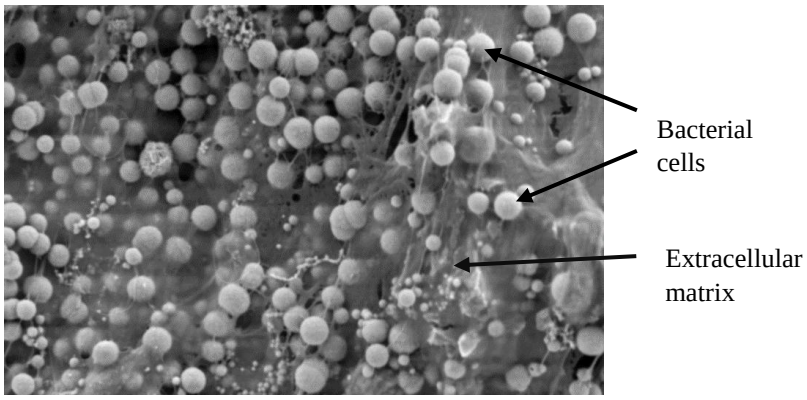
BIOFILMS- A FRIEND OR FOE?

Dinusha Kanatiwela
Board of Study in Plant Sciences

What is a biofilm?

A biofilm is basically defined as a structured community of microbial cells enclosed in a matrix of extracellular polymeric substances (EPS), growing on a biotic or abiotic substrate.

However, the best and the simplest definition given for a microbial biofilm has been put forward by Watnick and Kolter, in 2000 who have defined biofilms as "city of microbes" (Watnick and Kolter, 2000). They have described several similarities between a biofilm and our own city in terms of colonization, development, structure and function. The very first step in human colonization is the selection of a proper city which is followed by the selecting neighborhood which fulfills our requirements. Once we find a suitable place, we make our own home amongst many others and become stable. With time, a city becomes a heterogeneous complex and a stable structure which encompass various types of people, mode of transport, etc. These steps are common to the colonization of microbes, in which they first choose a suitable substrate (biotic / abiotic) in a suitable environment where they can get stabilized. This is followed by producing microcolonies, secreting different extracellular material to produce a complex, three dimensional robust structure in which they use water channels to transport nutrients and other waste products.



Scanning electron microphotograph of a bacterial biofilm
(http://dujs.dartmouth.edu/wp-content/uploads/2009/11/biofilm2_cmyk.jpg)

Where do we find biofilms?

Biofilms are ubiquitous in nature. They can be found in any place where conditions are favorable for their colonization. Living tissues, medical devices, industrial or potable water system piping, or natural aquatic systems or any other damp places are ideal residences for microbial colonization.

Biofilms – friend or foe?

Friendly biofilms

Biofilms play the role of 'the best friend' of engineers who develop water treatment systems. Microbial communities which comprise of bacteria, fungi, algae, and protozoa are utilized to breakdown pollutants in waste water through oxidation of organic particles and nitrification of ammonium (Nicolella *et al.*, 2000). The same phenomenon is adopted in bioremediation, such as cleaning oil spills (Tribelli *et al.*, 2012).

Farmers are benefitted by biofilms. Increased N_2 fixation in soybean has been observed when fungal-*Rhizobium* biofilms were applied than the single inoculation with *Rhizobium* sp. Phototrophic biofilms also provide benefits to the agricultural field in numerous ways. Increased water holding capacity in

soil by extracellular matrix of algal and cyanobacterial biofilms, use of cyanobacterial biofilms as soil fertilizers are some of the examples (Roeselers *et al.*, 2008).

In industry, biofilm reactors are used in the production of value added products, such as ethanol, acetic acid, fumaric acid, lactic acid, citric acid cellulose, amylase and lipase (Qureshi *et al.*, 2005).

Enemy biofilms

Unwanted biofilms create enormous problems in various areas including medical, environmental and industrial fields.

In healthcare fields, microbial colonization is of great concern since a vast spectrum of hospital-acquired human infections are due to the development of either bacterial, fungal or mixed biofilms. Systemic implanted devices *viz*. intravascular or urinary catheters, endotracheal tubes, or dental prosthesis provide excellent substrates for the establishment of biofilms which lead to various secondary infections in the host body. Contact lenses and dentures are superficial devices which may harbor biofilms resulting in ocular diseases and denture stomatitis. Dental plaques, which are the yellow colour slimy deposits in the tooth surface are frequently found amongst people with poor oral hygiene. These dental plaques consist of a mixture of microbial biofilms, mucus and food material. Sometimes effects of these robust microbial communities can also be life threatening. Colonization of microbes on native heart valves is one such example which may collapse the function of the heart. The threat posed by biofilms in medicine is their high resistance to the antimicrobials making the treatment of biofilm-associated infections challenging (Cernohorska and Votava, 2002; Bryers, 2008).

Biofilms have negative effects on industrial systems such as equipment, pipe systems used to transport resources and air ventilation systems. Enhanced material deterioration (biofouling), accelerated corrosion and increased fluid frictional resistances resulted by biofilms microbial colonization in industrial ventures are responsible for a waste of over billion dollars per year. Additionally, biofilms associated with food industry, pharmaceutical industry and water filtration and transporting systems may harbor pathogenic microbes. Possible health risk to consumers due to product contamination by those pathogenic organisms cannot be ignored (Coetser and Cloete, 2005; Schlegelova and Karpiskova, 2007).

Thus, some of the biofilms which exist in nature act as friends while some act as enemies**.** Hence, currently a large number of research studies are in progress to identify the control strategies to battle with bad biofilms and also to discover possible benefits of good biofilms which still remain unexplored.

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DIVERSITY OF *NYMPHAEA L*. SPECIES (WATER LILIES) IN SRI LANKA

D. P. G. Shashika Kumudumali Guruge
Board of Study in Plant Sciences

Water lilies are aquatic herbs with perennial rhizomes or rootstocks anchored in the mud. In Sri Lanka, they are represented by the genus *Nymphaea* L. It has two species, *N. nouchali* Burm. F. and *N. pubescens* Willd (Dassanayake and Clayton, 1996). Water-lilies have been popular as an ornamental aquatic plant in Sri Lanka from ancient times as they produce striking flowers throughout the year. In addition to these native water-lilies, few ornamental species are also been introduced in the past into the water bodies.

*Nymphaea nouchali (*Synonym- *N. stellata)*

N. nouchali has three colour variations, white, pink and violet blue. They are commonly known as "Manel". According to the field observations pink flowered *Nymphaea* is not wide spread like others. Blue and white *Nymphaea* are widely spread mainly in dry zone, Anuradhapura, Polonnaruwa, and also in Jaffna, Ampara, Chilaw and Kurunegala. Among these, pale blue flower *Nymphaea* or "Nil Manel" is considered as the National flower of Sri Lanka.

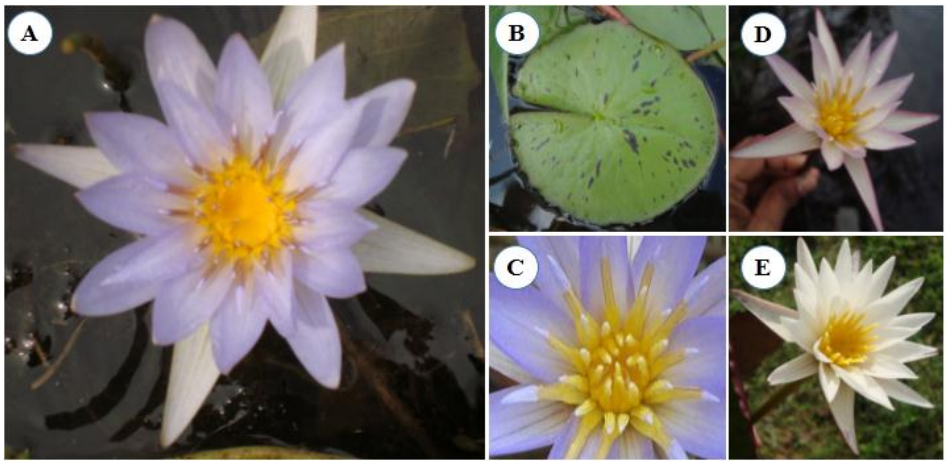

Figure 01. (A)- Pale blue flowered *N. nouchali*, (B)- upper surface of the leaf, (C)- Stamens having tongue shaped appendages, (D) Rose flowered *N. nouchali* , (E) White flowered *N. nouchali*

Some morphological characters of *N. nouchali* (Sri Lankan National flower) are given below and illustrated in fig. 01; A- flower, B- leaf, and C- stamens.

Flower : Diameter 20- 30cm.
Petals : 8-30in number, Pale blue colour, linear shape , 3-6cm in length 0.7- 1.5cm width .
Sepals : 4 in number, with purple streaks.
Stamen : 8-40 in number. Blue colour tongue shaped appendage on the top.
Leaf : Linear to lanceolate, upper surface light green, lower surface dark purple colour, entire margin

N. pubescens

N. pubescens is commonly known as "Olu". They are distributed throughout the island and abundant in the dry zone. The flower colour of *N. pubescens* varies from white to pink to yellow. Flower has 8-30 petals and 30-90 stamens. Anthers are yellow in colour and have no appendages.

Leaves have sharply dentate margin and abaxial surface is pubescent (with many short hairs) [Figure 02 (F) and (G)].

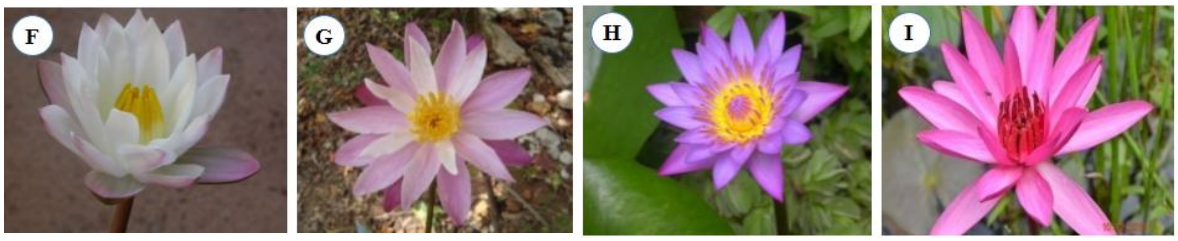

Figure 02. (F) White *N. pubescens* , (G) Rose *N.pubescens,* H) Introduced purple flowered *Nymphaea* and (I) Flower of newly recorded *N. rubra*

Purple flowered *Nymphaea* is an introduced ornamental flower. Now it is naturalized throughout the island. This flower is erroneously identified as *N. nouchali* and in some local literature this flower is used to depict the national flower (Yakandawala and Yakandawala, 2011) [Figure 02 (H)].

N. rubra share similar morphological characters with *N. pubescens* (Hossain *et al.,* 2000). Therefore this flower is also commonly known as "Ratu Olu", but colour of the petals, number and the size of the stamens, size of the flower and leaf, and veination patterns in leaves are significantly different between these two species so that one can easily distinguish these two from each other. However, *N. rubra* has not been recorded in local literature until recently [Figure 02 (I)].

Natural threats for native water lilies

Native *Nymphaea* species are widely used as offering to the lord Buddha and they are also used in ayurvedic medicine. In some areas rhizomes and petioles of *Nymphaea* are used as foods. However there are many threats for local *Nymphaea* species. Many water bodies are been destroyed due to construction of highways and other developmental projects. Further some invasive aquatic plants invade the habitats of native *Nymphaea* species. As an example purple flowered introduced *Nymphaea* species produce new plants by epiphyllos leaves, and they show rapid growth compared to native species (Yakandawala and Yakandawala, 2011). Especially it limits the natural habitats of *N. nouchali* and act as a silent invader. By protecting natural water bodies and by monitoring we can protect this diverse population of attractive and useful water lilies.

Acknowledgment

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HOW TO PLAN A HYDROPONIC GARDEN?

Kusinara Wijayabandara
Board of Study in Plant Sciences

Soil is the most available and highly used growing medium. It enhances proper root functions, supply water, adequate oxygen and nutrients to plant while providing physical support to the plant. However, there are limitations for plant growth in certain soil media such as, presence of soil born pathogens which cause plant diseases, poor water drainage, soil erosion and poor soil fertility. Hydroponics is an alternative method which can reduce the drawbacks of conventional method of growing plants. It is a technique which is used to grow plants by using liquid nutrient solutions with or without artificial medium such as coir, perlite, sand, gravel that provide physical support to the plant. The term "hydroponics" was practiced many centuries ago in different countries in the world such as Amazon, Babylon, Egypt, China and India. This word was derived from Greek as 'Hydros' (water) and 'Ponos' (working). In 1929, Dr. William F. Gericke introduced a laboratory technique of hydroponics into commercial horticulture (Roberto, 2013). Gradually this technique has been developed and home hydroponic kits were introduced during 1990s.

The basic types of hydroponic systems are Wick, Water Culture, Ebb and Flow, Drip (recovery or non-recovery), Nutrient Film Technique (N.F.T.) and Aeroponics. The Wick system is the simplest passive type hydroponic system. The nutrient solution is drawn into the growing medium (perlite, vermiculite, coir dust) from the reservoir with a wick (absorbent material). This system is most suitable for small crops. The water culture system is the simplest, active hydroponic system which is actively passing nutrient solution over plant roots. Plants are established on a platform which is made up of Styrofoam. Plants float directly on the nutrient solution. Oxygen is supplied by using an air pump. Fast growing, aquarium plants are the most preferred for this system (e.g. Leaf lettuce). In Ebb and Flow system the nutrient solution is pumped into the grow tray which contains aggregate medium. Then it floods the root zone temporally, and then allowed to drain back into the reservoir. However, most widely used type of hydroponic system in the world is Drip system. In this system, a timer controls a submersed pump. It turns the pump on and nutrient solution is dripped onto the base of each plant by a small drip line. Moreover, when we consider N.F.T. system the nutrient solution is pumped into the growing tray (slightly slanted tube) and flows over the roots of the plants, and then drains back into the reservoir. The aeroponic system is probably the most high-tech type of hydroponic gardening. It's growing medium is primarily air. The roots hang in the air and are sprayed with nutrient solution at regular intervals (Goto *et al.,* 1996).

Lettuce growing in NFT system
http://www.roatanisland.net/hydroponictour.htm

Hydroponic garden
http://www.roatanisland.net/hydroponictour.htm

The plants established in hydroponic system absorb nutrients from the solutions which are provided by the system. These solutions should contain macro and micro nutrients which enhance plant growth. Albert's solution is the mostly used solution in Sri Lanka. It contains NO_3^-, Mn^{2+}, $B_2O_7^{2-}$, Zn^{2+}, Cu^{2+}, Mo^{3+}, NH_4^+, PO_4^{3-}, K^+, Ca^{2+}, Mg^{2+} and SO_4^{2-}. Management of nutrient solution is an essential

factor in hydroponics in order to get high quality yield. However, pH level and electrical conductivity (EC) are the major factors which contribute in nutrient solution. (Saparamadu *et al.*, 2010). The optimum pH range for hydroponics nutrient solution is between 5.8 and 6.5 while the ideal EC range for hydroponics is between 1.5 and 2.5 dS/m (Department of Agriculture, 2014). There are many advantages and disadvantages of hydroponics.

Advantages of hydroponics:

- Absence of soil borne diseases
- Weeding is not necessary
- Off-season production is possible
- Water wastage minimum
- Less labor
- High yield

Limitations of hydroponics:

- Higher initial capital expenditure
- Need high degree of management skills
- Disease can spread easy
  Ex: Root rot diseases caused by *Phythium* sp.

When planning a hydroponic garden, should select a suitable space with minimum six hours sunlight. Furthermore, the effect of weather conditions including temperature needs to be considered. The hydroponics became more popular in a short period of time and this technique lead to begin indoor and outdoor hydroponic gardening very rapidly.

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CYCLIC SUCCESSION IN SALT MARSH VEGETATION INVOLVING *HALOSARCIA INDICA* AND SALICORNIA *BRACHIATA* IN SRI LANKA

Mathuranthini S.
Board of Study in Plant Sciences

Salt marsh vegetation is a type of marine vegetation found closer to the sea, which is regularly inundated by sea-water and composed of deep mud and peat. In Sri Lanka this area is dominated by dense stands of halophytic plants: *Halosarcia indica (synonym: Arthrocnemum indicum)*, *Salicornia brachiata* and *Suaeda* spp. (Dassanayake and Fosberg, 1987).

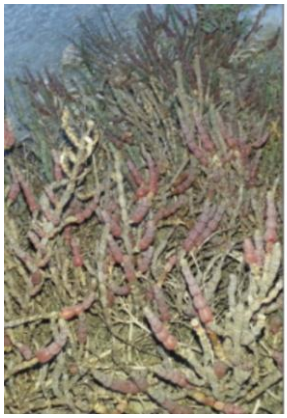

Figure 01: *Halosarcia indica*

Figure 02: *Salicornia brachiata*

Halosarcia indica (Arthrocnemum indicum) is a perennial herb with woody base. It has prostrate and erect shoots, becoming corky with age (Figure 01). *Salicornia brachiata* is an erect annual herb with much branched shoots. Woody base is not commonly found (Figure 02). When consider the vegetation dynamics of salt marshes in Sri Lanka these two species (*H. indica* and *S. brachiata*) show a characteristic sequential change called cyclic succession (Pemadasa *et al.*, 1979).

Cyclic or non-directional succession means small number of species replaced by each other over short period of time (Glenn-Lewin *et al.,* 1992). This cyclic succession begins without any large environmental interruption, which is required for other successions. Each species follow a series of phases *viz*; pioneer, building, mature and degenerate (Watt, 1947; Kershaw, 1975).

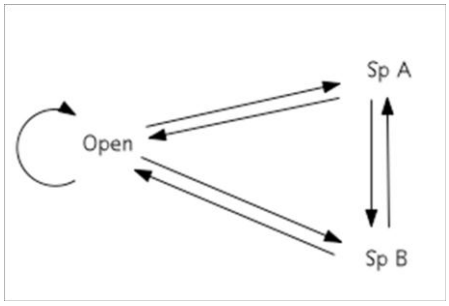

Figure 03: Graphic Model of Cyclic Succession (http://en.wikipedia.org/wiki/Cyclic_succession)

During the pioneer phase, starting with *H. indica* as an example, first plant begins to grow from seeds, which are blown in by the wind or washed in by sea. In the second phase (building phase), pioneer species grow, ages, and alters its surroundings where they enter into the mature phase. Further, in this phase the first species may develop space and second species start to germinate. During the final degenerating phase, the firstly grown dominant species degenerates and dies, paving way to the second species to dominate (Figure 03).

The phase development of *H. indica* incorporated with the 'hummock and hollow' cyclic change of environment. When *H. indica* begin to grow as a pioneer plant, sand particles brought in by the wind accumulates around its seedlings and get trapped. Eventually this results in the development of hummocks and *H. indica* enters into its next phase. When *H. indica* is in its building and mature phases other plants cannot grow or colonize well. The erect branches maintain the general level of the hummock. Wind erosion is prevented by the prostrate shoots that cover the entire hummock (Figure 04 and Figure 05).

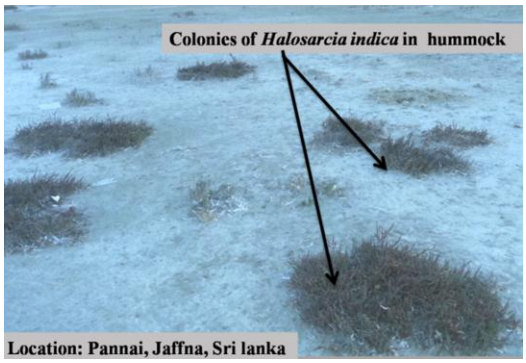

Figure 04: Colonies of *Halosarcia indica* in hummock

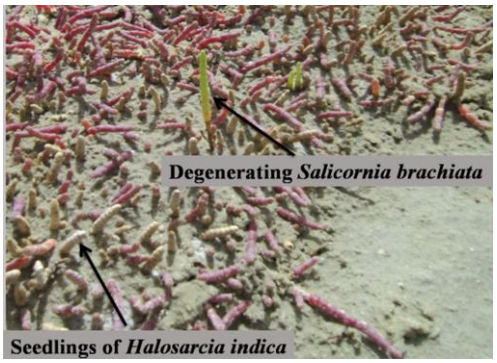

Figure 05: Pioneer phase of *Halosarcia indica*

However, shoots of *H. indica* become less firm and produce smaller branches when the plant is ageing. Therefore the centre of old hummock becomes moderately open. But the boundary of open area is covered by well branched, properly growing shoots and these prevent the wind erosion (Figure 06 and Figure 07).

Figure 06: Building and early mature phase

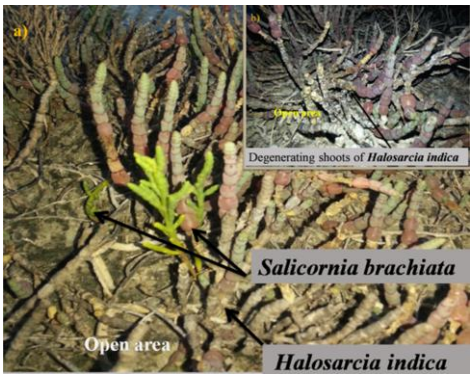

Figure 07: a) Mature and degenerate phase,
b) Degenerating shoot of *Halosarcia indica*

The open areas created by the death of the older shoots of *H. indica* are colonized by the second species *Salicornia brachiata* associated with *Cynodon dactylon*. These do not prevent wind erosion and therefore eventually hummock begins to erode, where the hummock becomes more or less flattened and hollow. This initiate a new cycle which goes through the same sequence of pioneer, building, mature and degenerate phases (Figure 08 and Figure 09) (Pemadasa *et al.*, 1979).

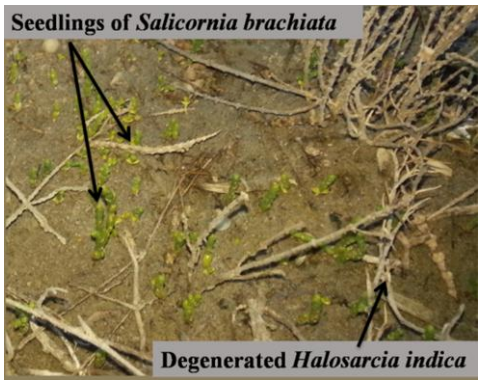

Figure 08: Colonization of *Salicornia drachiata*

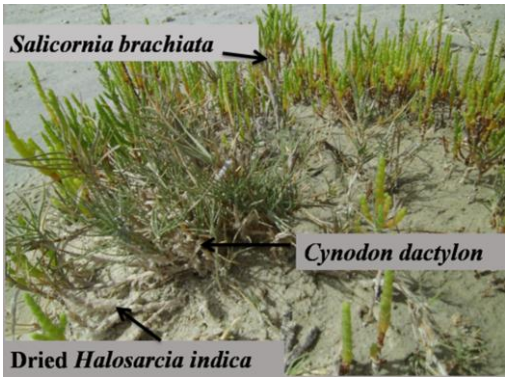

Figure 09: Established colony of *Salicornia brachiata*

Note: This cyclic succession was observed and photographs were taken during my field visits (June 2013-Feb 2014) in Jaffna peninsula at Pannai area.

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I would like to express my special thanks to my supervisor professor D. M. D. Yakandawala, Department of Botany, University of Peradeniya for her encouragement in writing of this article and I am thankful to Mrs. N. Ravimannan, Department of Botany, University of Jaffna for her valuable advice.

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FRUITS OF ORCHIDS: HAVE YOU EVER NOTICED ?

W.A. Menaka Ariyarathne
Board of Study in Plant Sciences

Orchids or Orchidaceaes are the members of family Orchidaceae which is one of the largest plant families of flowering plants in the world. Orchids got their name from Greek "Orchis" which means "testicle". It was first stated by Theophrastus (372/371–287/286 B.C.), the father of botany and ecology in his "De historia plan tarun" (The natural history of plants). According to the latest updates published by Royal Botanical Gardens of Kew in collaboration with Missouri Botanical Garden (The Plant List, Version1.1), there are 925 genera of orchids within the family Orchidaceae containing around 20,000 species and countless hybrids. As published by S. S. Fernando and Paul Ormerod (2008), Sri Lanka owns 188 species belonging to 78 genera with one endemic genus and 55 endemic species. Orchids are cosmopolitan in distribution, occurring in every possible habitat except Antarctica and deserts. Even though these plants are famous as epiphytes or air plants which grow on trees (a), also they are subsisting in some other places as well (Fig. 1). Orchids that grow on rocks by clinging to the rock surface are called lithophytes (b). Those grown in mulch, often on the forest floor are called saprophytes (c) and in addition there are terrestrial orchids (d), which grow on soil or sand.

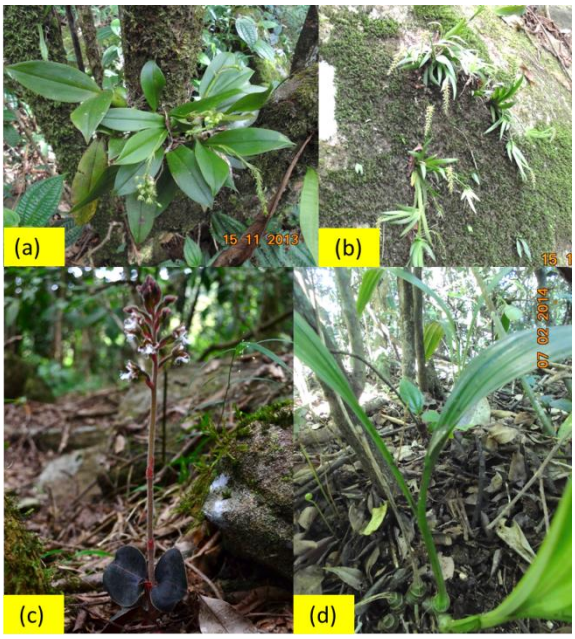

Figure 01: differant habitats of Orchids (a). An epiphytic orchid (b). A lithophytic Orchid (c). A saprophytic Orchid (d).A terrestrial Orchid

Members of this family are unique among other plants in the nature and show a vast diversity among the members within the family. They are classified as perennial herbs. Orchids occupy the top position of all flowering plants. Most of them are well known for their bright, characteristic blossoms which come with different shapes, colors, sizes and fragrant smells.

Figure 02: Pseudo-copulation (a). *Ophrys speculum*, the Mirror Bee Ochid (b). Pollination by a bee

A basic orchid flower composed of three sepals in the outer whorl, three petals in the inner whorl. However the middle petal has deviated from others by producing a labellum or a lip. This lip can be developed either in the same color as the flower or in a contrast color. These specializations in colors and structures have resulted in unique pollination mechanisms. One such mechanism is pseudo-copulation in which flower mimics a potential female mate visually but inducing factor is a chemical. The best example for this senerio is *Ophrys speculum*, the Mirror Bee Orchid. Some other pollination mechanisms are self pollination and cross pollination. Even though self pollination take place within the flower, for cross pollination orchids depends on pollinators. The pollinating agents may be insects (Lepidoptera, Diptera, and Hyrmenoptera), birds, and possibly bats.

At the end of a successful pollination and fertilization, fruits are developed. Size of the fruits or in other words capsules deviated from very few millimeters to some centimeters. It may depend on size of the flower (Figure 03). Some species contain large number of capsules in one spike while some others contain very few depending on the number of fertilized flowers. Each capsule consists small (microscopic), dusty and transparent seeds (Figure 04). Therefore investigation on these seeds can be carried out only with scanning electron microscope (SEM). For example, seeds of *Ophrys mammosa* are 0.557 µm in length and 0.138 µm in width. Its embryos are smaller than the seeds: 0.107 µm in length and 0.062 µm in width. These seeds can travel a great distance in the air due to their fusiform, aerodynamic features and above mentioned light weight properties (Aybeke, 2013).

Figure 03: Differant sizes of Orchid fruits/ capsules

Some epiphytic orchids of the tropical rain forest produce the world's smallest seeds weighing only one 35 millionths of an ounce (1/35,000,000) or 0.81 micrograms. These minute seeds dispersed in to the air like dust particles or single celled spores and eventually reach and rest in the upper canopy of the forest trees.

Figure 04: Seeds of a *Dendrobium*

Germination of Orchid seeds under natural circumstances require special conditions. Since they are so tiny, these seeds do not contain endosperm and undeveloped embryos, practically they have no food (Energy) reserves other than small lipid droplets and endogenous or exogenous supply of cytokinin that is essential for the lipid mobilization. Therefore in order to germinate they must establish a symbiotic relationship with a compatible mycorrhizal fungus.Most of them are classified in the form-genus *Rhizoctonia*. This group includes anamorphs of *Tulasnella*, *Ceratobasidium*, and *Thanatephorus.* At the begining of the germination the fungal patner of the symbiotic relationship provides critical nutrients to the orchid partner. Eventually the orchid may become fully independent, or it may retain its mycorrizal relationship throughout its life. However orchids utilize fungus to stimulates the seed germination and seedling development by allowing the fungal hyphae to enter in to seed via micropores. Then the fungal hyphae grow inside the inner embrayonis cells as little coils called peletons. The orchid simply digests these peletons . With the new supplements Orchids start to develop a shoot with roots and leaves (Figure 05). Peletons are sufficient for Orchid seedlings as a carbon source until the chlorophyll in the leaves have developed, this can take from months to an eternity as some orchids never produce chlorophyll (*Dipodium punctatum* and *Gastrodia sesamoides*). Dependency on the fungal partner could be annihilated once the orchid reaches maturity. Especially, while epiphytic orchids are known for losing the need for peletons, terrestrial orchids typically keep the relationship going until death does them part (Otero, 2002).

Figure 05: A seed of *Ochis mascula* in the soil with root hairs and hyphea

As the fields of Orchidology and seed biology develope, scientists were able to come up with alternatives for this essential symbiotic relationship between orchids and fungi. Development of Maceration technique using seeds of Barlia robertiana by Mehmet Aybeke (2013) from Turkiye and also by a Taiwan research team has established an efficient method of propagation via asymbiotic germination of seeds in vitro for medicinally important Orchid species called Dendrobium tosaense (Lo *et al*., 2004). An Indian research team also has developed an asymbiotic germination technique as a step for ex-situ conservation of endemic Orchids in India (Shibu *et al*., 2012). Royal Botanical Gardens of Peradeniya, Sri Lanka also propagates Orchids for industrial purpose using Murashige and Skoog medium and Knudson C medium. Using these specialized mediums seeds were given with all the nutrients required for the development of roots and leaves until the plant become stable and self sufficient.

However as a family with exceptional characteristics members of family orchidaceae were able to preserve their uniqueness even through the fruits and seeds.

Acknowledgment

A special acknowledgement goes to project superviser Prof. D. M. D. Yakandawala, Department of Botany, University of Peradeniya and National Research Council (NRC 12-121) for financial support.

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VILLU IN MAHAWELI FLOODPLAINS- OASIS OF DRY ZONE FORESTS

Shalini Rajakaruna
Board of Study in Plant Sciences

Sri Lanka is an island which is endowed with numerous ecosystems from montane forests in mountains to large dry zone forests in the lowlands, and beyond. The island is nourished with 103 rivers running across the country from the central hills to the ocean. Out of these, the river 'Mahaweli' which rises at mount 'Samanala' and reaches the Bay of Bengal, forms the largest river basin in Sri Lanka, covering almost one fifth of the island. When the northeast monsoon brings rain to northern and eastern slopes of the hill country, the River Mahaweli reaches its maximum water levels and floods over to cover the dry zone forests in downstream of the north central province, creating the most beautiful wetland ecosystems of the island- 'Villus' in the Mahaweli flood plains. Besides the man-made tanks in the dry zone, 'villus' are the only natural inland water bodies found in Sri Lanka that provide food, water, fiber, medicine, in addition to aesthetic, spiritual and recreational values, that support livelihoods of locals. Villus are marshy areas which occur in association with the riverine floodplain, occupying the natural river levees. Each villu consists of a pool which is more or less filled with water throughout the year and marginal floodplain which is inundated only during the floods. These pools are saucer shaped depressions and in other parts of the world, they are called "ox-bow lakes". Most of the villus directly connects with Mahaweli or its tributaries via small channels. When the water levels of the river increase, the villus are fed with water and during periods of low river flow, water drains back to the river through these channels. There are more than 38 villus identified downstream of Mahaweli River and they occupy a total area of 12,800 hectares. Some of the smaller villus become dry periodically while larger ones retain water throughout the year. The dynamic nature of the villus causes them to be unique wetland ecosystems which add glamour to the scenic beauty of the dry zone of Sri Lanka, while providing favorable feeding and breeding grounds for many wild life species.


A beautiful morning view of Handapan villu

The distribution of vegetation in villus shows an exclusive characteristic pattern whereby plants grow in three distinct zones. At the outer margin, essential terrestrial grasses, herbs and shrubs like *Sida sp., Urena sinuata, Abutilon pannosum*, *Cymbopogon nardus* and *Ziziphus oenoplia* can be found. Gradually they are replaced by water loving grass and herb species like *Cynodon dactylon, Ludwidgia sp. Schoenoplectus grossus* and *Ipomoea aquatica.* At the innermost zone true aquatic plants like *Eichhornia crassipes*, *Hydrilla sp.*, *Nymphoides hydrophylla* are found. In the mid zone large trees of *Terminalia arjuna* and *Barringtonia acutangiila* stand in the moisture rich ground, giving shade to the saplings and herbs and also facilitating the raptors to perch and hunt. The grasses in villus are important as food for the cattle, water buffalos and other wild herbivores. However in some of the villus that are impacted by the damming of river Mahaweli, the grasses are replaced by a weed species, *Xanthium strumarium,* because of the absence of prolonged flooding. This weed is not suitable for grazing for wild herbivores because of the many-hooked seed clusters. The local communities living in the bordering villages are immensely benefited by the vegetation growing in villus. Herbs like *Ipomoea aquatica, Alternanthera sessilis and Cardiospermum halicacabum* add minerals and vitamins to the diet of the locals while medicinal herbs *like Aerva lanata, Rhinacanthus nasutus, Hemidesmus indicus* cure their illnesses. Extracting cane from *Calamus sp.* which is abundant in marginal vegetation of villus, is a common profession among the villages in Pollonnaruwa district. Village women


A villager extracting cane from a shrub of *Calamus* sp.

make baskets, mats etc. using the leaves of *Schoenoplectus grossus* (Thunhiriya) which is another common plant species in villus.

Birds are the voice of silent villus that gives life to the quiet waters. The calls of cranes, stalks and water hens gathered in the pools of villus indicate the availability of food for the water birds as well as for the birds of prey. The migratory season is a festive time in villus where a large number of migrant birds stop by to feed, breed and to rest. Large flocks of painted stalks that assemble in villus create a spectacular view and the colourful purple swamp hens and pheasant-tailed jacanas that walk on floating plants searching for food, make the picture lavish. The common migrants recorded in villus include *Anas querquedula, Pluvialis dominica fulva, Charadrius dubuis, Limosa limosa.* Birds of prey often sighted in villus are *Pandion haliaetus*, *Haliastur Indus, Spilornis cheela* and *Ichthiophaga ichthyaetus.* Not only for birds but also for many freshwater fishes of the Mahaweli river basin, villus are ideal habitats rich with food and breeding grounds. The fishes in mahaweli villus include the endemics such as *Channa orientalis, Pethia cumingii* and *Belontia signata***.** Number of villus support full time fishing activities of the locals who totally depend on inland fisheries.

At present, as any other ecosystem in the world, villus are also at threat due to the anthropogenic activities. As a result of damming of the river Mahaweli, there has been no prolonged flooding in recent years. This has caused a serious impact on some of the villus, as the prolonged floods are the main source of water for the villus. Replacement of water loving vegetation with terrestrial species like *Bauhinia racemosa* can be observed in villus, indicating the lower ground water availability in the floodplains. The continuous dry conditions in villus may change the unique characteristics of the ecosystem and that may even lead to extinction of some villu associated flora and fauna in future. Therefore the right time has come to draw our attention to protect and conserve this unique ecosystem which serves both human and wildlife equally.

Note: This article was written based on my personal observations during my field visits to Villus in Floodplains National Park.

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SYNCHRONIZED FLOWERING AND MASTING BEHAVIOR OF *STROBILANTHES* (NELU)

Yasoja Athugala
Board of Study in Plant Sciences

Horton Plains gives a unique and rare opportunity for thousands of local and foreign tourists including nature lovers after 12 years with a cover of white, pink and purple carpet of Nelu flowers during September-December, 2013. Nelu flowers normally bloom once in 12-14 years and before the flowering observed in this year, full bloom of flowers was observed in 2001. Further, there are records of Nelu flower bloomings in 1881, 1893 and 1905. Therefore, the Horton plains will be lucky to adorn again with this Nelu flower carpet in year 2024.

Image 01: Bloom of Nelu invite nature lovers to visit the Horton Plains and enjoy the beauty of the flowers after 12 years, in 2013. (Photo: YRF Annual trip in 2013.11.14)

Nelu, which is also known as Nilu or Nilla in sinhala, belongs to the genus *Strobilanthes* and to the family Acanthaceae. There are around 130 *Strobilanthes* species throughout the world. However it occurs mainly in the Asian region. There are 31 species of *Strobilanthes* in Sri Lanka and of them, 26 are endemic.

The flowering of *Strobilanthes* marks the death of the mother plant. It means that flowering and fruiting only occurs once in the life span of this plant. Those type of plants are known as monocarpic or semelparous plants. According to the life cycle, plants can be divided as annuals, biannuals and perennials. An annual plant completes its life cycles (germination, flowering and seeds production) within a year, a biannual plant takes two years and a perennial plant lives for more than two years. Most annual and biannual plants flower once and die. Based on the flowering pattern, perennial plants can be further divided into two as monocarpic and polycarpic (iteroparous). However, polycarpic plants flower and set seeds many times during its lifetime while monocarpic plants flower only once and die. Some species of Bamboos, *Strobilanthes*, *Agava* and *Lobelia* are some of the examples for monocarpic plants found in Sri Lanka.

Group behavior of flowering of the individual plants of the same species at the same time period in a certain geographical area is known as 'synchronized flowering' (McDonald and Kwong, 2005). This phenomenon causes the production of a large mass of seeds in an area at a particular time period and it is called as mast seeding or masting. Masting, in the strict sense of the term, occurs only in monocarpic species. That synchrony occurs over long distances and involves almost every tree or occurs as a wave pattern. As synchronized flowering or masting is generally defined for one specific species, harmonized flowering in more than three species (*S. dianadra, S. calycina, S. hookeri, S. pulcherrima, S. viscosa,* etc.) in Horton plain at this time is a wonder.

Long pre-reproductive period is necessary to accumulate enough resources to produce a large number of flowers and seeds at the short masting period. It gains an evolutionary advantage of longer reproductive cycles which result in higher fitness compared to annually reproducing plants

Image 02: Harmonized flowering of *Strobilanthes* in Horton Plains in 2013. (A) *S. pulcherrima,* (B) *S. calycina* and (C) *S. viscosa.*

(Tsvuura *et al.*, 2011). Death of plants after reproduction signifies expending all the resources in reproduction. Death of the parent plants increases the available resources (space, light requirement, nutrition etc.) for survival of the offspring.

Tsvuura (2011) has encapsulated three hypotheses that have been forwarded to describe the evolutionary significance of synchronized flowering and masting.

1. The outcrossing hypothesis suggests that a large visual display associated with synchronous flowering increases the chances of cross-pollination. Cross pollination allows diversity within the species, as the genetic information of different plants are combined. Therefore, it benefits the parent plant by producing high quality seeds and off springs with high vigour.
2. The predator satiation hypothesis proposes that synchronous reproduction in long-lived species produces more seeds than that can be consumed by seed predators during masting years, and starves the seed predators in non-seeding years. Predator satiation is an anti-predator adaptation in circumstances where prey occurs in high population densities. Masting reduces the probability of an individual organism being predated.
3. A third hypothesis is that interspecific competition may have driven the evolution of reproductive synchrony in monocarpic species. The dominance of monocarpic species in the community is maintained by synchronized mass reproduction and seedling establishment, which excludes seedlings of other species beneath the parent plants. As the parent plants die, their seedlings are released from competition.

There is a question on how masting trees manage to coordinate the same cycle over a large area. However, no clear evidence to reveal that how plants pass signals to synchronize the flowering through long distance. Three mechanisms are germane to discuss the mechanism of synchronization of activities among plants or animals: chemical, reproductive and environmental. A Recently, completed studies have revealed that chemical and reproductive mechanisms are not enough

Image 03: Synchronize flowering of *Strobilanthes Kunthiana* in Western Ghats, India. It blooms once in 12 years. *(http://floralbasket.blogspot.com)*

to explain the synchrony of masting in observed distances. Geographically wide-ranging climate conditions cause trees to mast in synchrony (Isagi *et al.*, 1997; Schauber *et al.*, 2002). There is evidence to say that temperature may be a key parameter. The scientist consider that the periodic fluctuations of temperatures (perhaps caused by the cyclic El Nino phenomenon) operate in synchronization with masting over the same geographic area (Schauber *et al.*, 2002). However, the mechanism of this interesting behaviour is still to be known.

Acknowledgment

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CORROSION SENSORS

Chamaal Karunaweera
Board of Study in Chemical Sciences

A corrosion sensor can be generally defined as a device that shows a response that can be recorded upon corrosion of an object. Corrosion sensors can be either embedded in the object to be monitored or placed in the environment to be monitored. Ease of handling and corrosion monitoring of inaccessible objects provided by the corrosion sensors is an important advantage of a corrosion sensor. Moreover, low cost, rapidness, reproducibility and sensitivity are some other important disadvantages of corrosion sensors. Considering these, scientists moved towards the production of corrosion sensors, which can be used as systematic corrosion monitoring tools. Corrosion sensors are now used in many instances, where corrosion is a serious concern for the quality or the strength of objects, such as aircrafts, oil refineries, bridges and some buildings made up of concrete.

Use of traditional corrosion sensors are still applied, even though there are modern sensing techniques. The simplest traditional corrosion monitoring technique is the use of sacrificial anodes placed at different depths. This is commonly used for corrosion monitoring of reinforced concrete structures, where anodes are externally connected to a suitable cathode and the currents generated are monitored. Ion meters or ion sensitive electrodes placed in the surrounding area of a metallic object is another type of simple and conventional corrosion monitoring technique. Oxygen transport technique which involves the determination of the rate of oxygen transfer on the object is another important sensing technique. Humidity sensors are a different type of traditional sensor which measures the humidity of an environment in which a metal is corroded. In most cases, these traditional corrosion sensors are used to detect corrosion of metal bars in concrete structures (Broomfield, 2002).

Corrosion sensor embedded in a concrete structure

Chip type corrosion sensor

With the need of advanced corrosion sensors, more sophisticated methods have been developed which result in modern corrosion sensors. In every year, a number of corrosion sensors are introduced into the market by researchers. These include novel magnetic corrosion sensing methods and fiber optics based sensing methods, which are more efficient than conventional corrosion sensors (Gupta and Verma, 2009). Superconducting Quantum Interface Devices (SQUIDs), hall sensors and magneto-resistive sensors are examples of magnetic corrosion sensing devices.

Corrosion sensor placed on a bridge.

Most modern corrosion sensing techniques are occupied to monitor corrosion of aircrafts, marine transportation, oil refineries and mineral oil power plants. As the above mentioned objects are exposed to highly corrosive environments, monitoring of corrosion is a major concern. Corrosion resulted on the wings

and the body of aircrafts is more rapid as the aircrafts are subjected to more corrosive medium in the atmosphere (Wilson *et al.,* 2008). Loss of strength of the body of aircrafts results in aging. Therefore, aircrafts may have to be kept out of service even before their expected life time is reached, if corrosion has taken place. Further, many sulphur and chlorine containing compounds are generated among the combustion products of coal and mineral oils, causing oil refineries to undergo severe damages due to corrosion. The damage could be severe that the breakdown of the structure of oil wells is possible. Wireless corrosion sensors have also been developed to monitor corrosion in such situations, especially at places which are not easily accessible.

Acknowledgment

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PHYTOREMEDIATION

Kanishka Gunasekara
Board of Study in Chemical Sciences

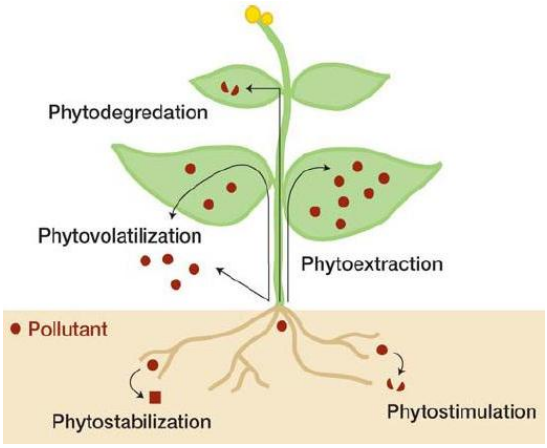
Heavy metals are individual metals and metal compounds that can impact on human health. Eight common heavy metals are arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. These are all naturally occurring substances which are often present in the environment at low levels. But, due to many human activities these levels have been elevated which can be very dangerous. Generally, humans are exposed to these metals by ingestion (drinking or eating) or inhalation (breathing). Working in or living near an industrial site which utilizes these metals and their compounds increases ones risk of exposure if the metal bases have been improperly disposed. Scientists are looking for many efficient and cost effective solutions to overcome this problem as it has become a big issue in many areas all over the world.

In this context *Phytoremediation* is a very interesting phenomenon that can be addressed a number of environmental problems due to heavy metals. Interesting advantage of this is the trapped metals can be extracted via special chemical methodologies so that the extracted small amounts of metals can be utilized as a bulk. Also, usability of low cost plants such as grass would be economical. Of course, this is not a novel technique and many countries such as South Africa, New Zealand, Canada, etc. have used this technique for various pollution control. As a developing country, such low cost methods must be adopted in Sri Lanka to mitigate the environmental pollution as our native plant species can be utilized in this regard.

Phytoremediation is the direct use of green plants and their associated microorganisms to stabilize or reduce contamination in soils, sludge, sediments, surface water, or ground water etc. In other words, phytoremediation encompasses microbial degradation in rhizosphere as well as uptake, accumulation and transformation in the plant. Pytoremediation is a natural process and an effective remediation method on numerous contaminants. However, sites with low concentrations of contaminants over large clean-up areas and at shallow depths are the especially favourable conditions for phytoremediation. Plant species are selected for this purpose based on factors such as ability to extract or degrade the contaminants of concern, types and concentration of contaminants, adaptation to local climates with high biomass and easy maintenance. The technique is commonly used to extract heavy metals such as Hg, Ag, Au, As, Pb and hazardous chemicals such as Cyanides. Depending on the application, appropriate native metal accumulating species (depending on the availability, geographic regions with varied weather conditions) should be selected for effective results.

A range of processes mediated by plants are useful in treating environmental problems:

- Phytoextraction: uptake and concentration of substances from the environment into the plant biomass.
- Phytostabilization: reducing the mobility of substances in the environment, for example, by limiting the leaching of substances from the soil.
- Phytotransformation: chemical modification of environmental substances as a direct result of plant metabolism. [often resulting in their inactivation, degradation (phytodegradation), or immobilization (phytostabilization)].
- Phytostimulation: enhancement of soil microbial activity for the degradation of contaminants, typically by organisms that associate with roots. This process is also known as rhizosphere degradation. Phytostimulation can also involve aquatic plants supporting active populations of microbial degraders, as in the stimulation of atrazine degradation by hornwort.
- Phytovolatilization: removal of substances from soil or water with release into the air, sometimes as a result of phytotransformation to more volatile and/or less polluting substances.
- Rhizofiltration: filtering water through a mass of roots to remove toxic substances or excess nutrients. The pollutants remain absorbed in or adsorbed to the roots.



Types of phytoremediation
http://systemsbiology.usm.edu/BrachyWRKY/WRKY/Phytoremediation.html

Application of Phytoremediation
http://www.letsgarden.info/info/ecology/phytoremediation.html

This technique is presently used in sewage and wastewater treatment, groundwater and soil treatment, etc. Yet, there is a number of areas where research is required. For example, the rate of biodegradation and mineralisation during phytoremediation is usually affected by the nature and concentrations of contaminants present, as well as surrounding oxygen levels, soil/air moisture, pH, temperature, soil elemental contents and their availability. Plant physiological and root growth expansion studies are needed to optimise plant uptake of contaminants and to maximise process output performance. Research is needed to determine the best density of plants per unit area to achieve the maximum utilisation of resources (too many plants can negatively adverse the processes, weaken the plants and be costly during disposal processes), and to determine the proper timing for irrigation and harvesting in order to control the amount of biomass produced and removed at harvest. Other areas requiring further research include the effect of fertilisers and conditioners on the soil characteristics and the fate of these compounds.

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ROLE OF ORGANOMETALLIC CHEMIST IN THE 21ST CENTURY TO MITIGATE CO_2 LEVEL IN THE ATMOSPHERE

M.Chandramalika Rukmali Peiris
Board of Study in Chemical Sciences

In the 21st century, one of the biggest problems faced by the world today is the rapid increase of the CO_2 level in the atmosphere. There are only a few natural sources such as plants which can absorb CO_2 and control the equilibrium of the atmosphere, but the number of sources that emit CO_2 to the atmosphere are more than the natural sources present to absorb it. Therefore the elevated level of CO_2 causes several detrimental effects such as greenhouse effect, acid rains, melting of glaciers and health issues such as lung diseases and cancers. Comparing to the other pollutants, CO_2 plays a significant role in air pollution. Green plants trap CO_2 by the photosynthesis in the day time and emit O_2 in to the atmosphere; this process will keep the balance of O_2 and CO_2 level in the air. In early 60's evaluation of the industrial age, diesel engines began to produce more CO_2 and CO in to the atmosphere, and at the same time deforestation and the use of diesel as a fuel made the air pollution worsen.

When the situation became critical, scientists tried to find out solutions for mitigating the environmental pollution caused by CO_2. Now many scientists are making efforts to find out solutions to mitigate CO_2 level in various ways. Here not only by natural ways but also some synthetic complexes similar to Chlorophyll is being synthesised (Srivastava, 2005; Peiris and Ganehenege, 2011(a); Peiris and Ganehenege, 2011(b); Peiris and Ganehenege, 2012) to do the same role that chlorophylls do in plants. In this context, synthetic inorganic chemists started the synthesis of transition metal macrocyclic complexes that can act as a catalyst similar to the natural sources. As a first attempt, researchers in our group (Dr. M. Y. U. Ganehenege and her research group) attempted to substitute Mg^{2+} centre of isolated chlorophyll (Figure 01) by transition metal ions and subsequent utilization of such complexes for efficient CO_2 binding (Gurusinghe, 2010).

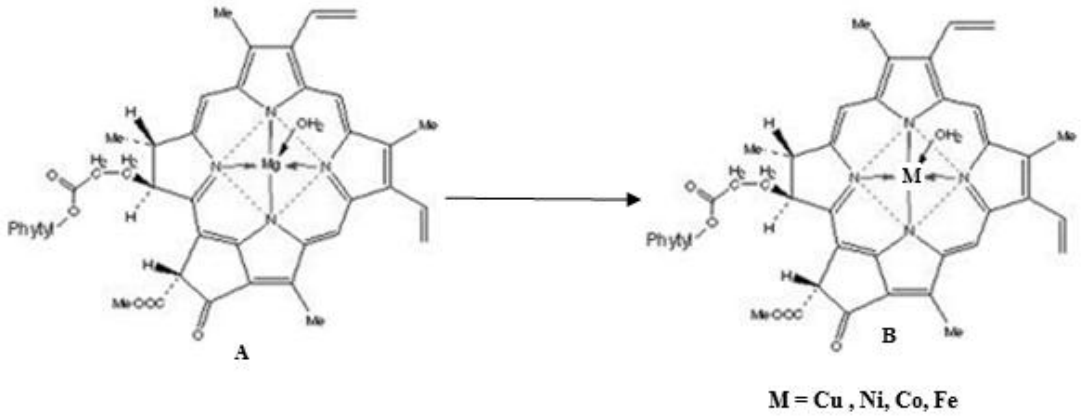

Figure 01: Chemical structure of the chlorophyll (A) and modified chlorophyll with transition metal ions (B).

However, in early days researchers attempted to synthesis the structures similar to chlorophylls artificially. For an example porpyrins and metalloporpyrins synthesis have been achieved by the "Adler and his research group" in 1966 (Adler *et al.*, 1967). Since then the porpyrin as well as pthalocynin (Figure 02) synthesis have been come along a long way with modifications to achieve many targets. Most of the complexes are nearly similar to the chemical and physical properties of chlorophyll.

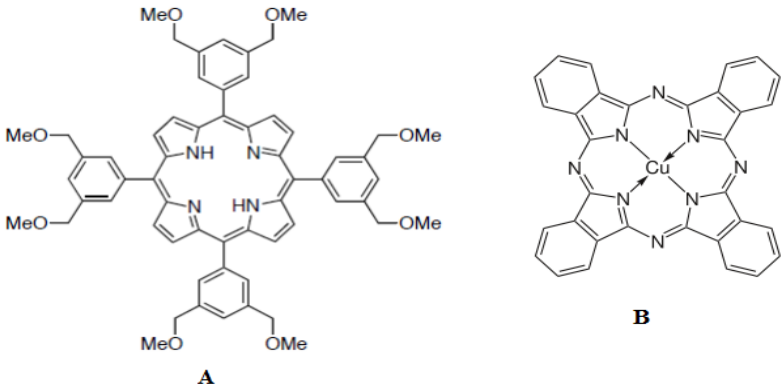

Figure 02: Structures of synthetic porpyrin ligand (A) and metal pthalocynin complex (B).

After synthesis of several types of macrocyclic complexes, next step was to use them as a catalyst to reduce CO_2. In here electrochemical reduction and photochemical reduction are the widely used methods. From these two methods, environmental friendly method is the photochemical reduction. The electrochemical method is efficient although it is expensive. Nevertheless, the final electrochemical product can be evaluated by using bulk electrolysis and spectroelectrochemical techniques. Therefore in the near future scientist may achieve CO_2 reduction by modifying efficient transition macrocyclic catalysts, to reduce CO_2 in to useful products such as formic or bicarbonic acid while reducing the CO_2 level in the atmosphere significantly. Not only porpyrin complexes, but also many organometallic complexes, schiff base complexes and metal macrocylic complexes have been reported to catalyse many electrochemical and photochemical transformations of CO_2 (Srivastava, 2005). Nowadays, the mitigating of CO_2 has become the turning point of the green chemistry in sustainable development.

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NANOSTRUCTURED HOLLOW INORGANIC MATERIALS

Prasanga Gayanath Mantilaka
Board of Study in Chemical Sciences

Inorganic materials containing porous structures (Holes) are known as inorganic hollow materials (Liu *et al.*, 2014). Most of these materials are prepared by fabrication of nanoparticles. Some examples for inorganic materials are calcium carbonate, titanium dioxide, carbon, silica, calcium phosphates/hydroxyapatite and their composites (Zhao and Wang, 2012). Hollow structures of these inorganic materials have potential applications in catalysis, sensors, lightweight fillers, confined-space chemical reactors, low-dielectric-constant thin films, photonic crystals, controlled drug delivery, biomedical diagnosis and therapy, anode materials in lithium ion batteries and so on (Hou *et al.*, 2010). Therefore, nanostructured hollow materials have gained a great attraction in recent years. One hollow inorganic material which can be used for numerous applications by filling its hole by various other materials depending on end use. For example, calcium carbonate hollow spheres are filled by various drugs in order to use as drug delivery systems. Herein, drug is encapsulated by calcium carbonate and hence, the drug is only released at the target infected cells. Another recent study reports that the carbon (graphite) nanocapsules can be used as an electrode material for hydrogen peroxide detection (Liu *et al.*, 2014). Herein, electrically conductive graphite capsule is filled by enzymes in order to use as a detector (Liu *et al.*, 2014). Hollow materials are mainly characterized with the help of Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). SEM and TEM images of few hollow inorganic materials are shown in Figure 01.

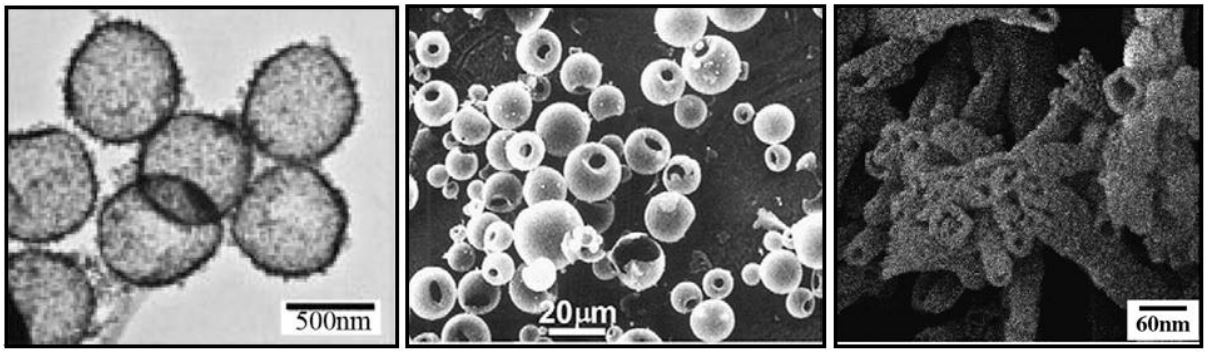

Figure 01: Electron Microscopic images of inorganic hollow materials in literature

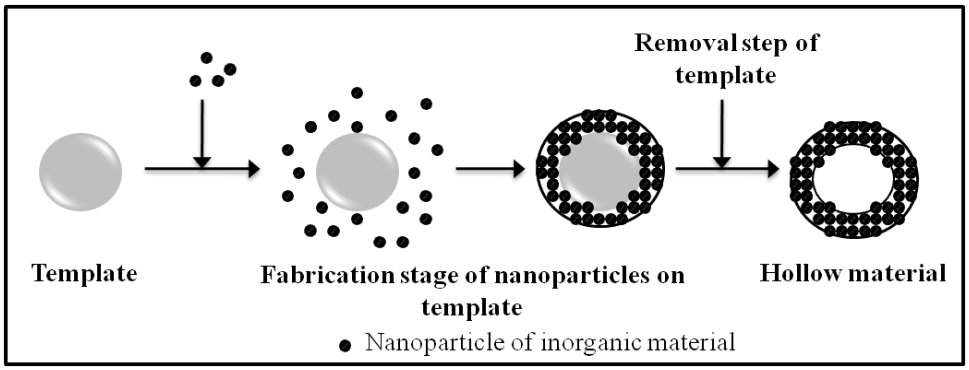

Figure 02: Formation mechanism of nanostructured hollow materials

Hole of the particle is produced using templates. Nanoparticles of the inorganic materials are fabricated on the template and later, after the fabrication, the template is removed from the system to form the hole. The formation mechanism is schematically represented in Figure 02. There are two types of templates as soft template and hard template (Hou *et al.*, 2010). Soft templates are in liquid or gas phase while the hard template is a solid material (Mantilaka *et al.*, 2014; Hou *et al.*, 2010). For example, silica nanoparticles are fabricated on calcium carbonate template and later, calcium

carbonate template is removed from the system by treating the final product with an acid in order to produce hollow silica (Zhao *et al.*, 2008). Herein, silica is acid resistant while the calcium carbonate is digested in acid. Polymer/surfactant template is the best example for soft template (Zhao and Wang, 2012). Herein, surface of surfactant micelles with a particular shape are covered by polymer chains to form the template (Mantilaka *et al.*, 2014). The nanoparticles of inorganic material are fabricated on the surface of polymer. After washing, surfactants are removed from the system (Zhao and Wang, 2012). However, sometimes, polymer remains in the final product. Therefore, polymer must be selected based on the purpose and final product. For example, calcium carbonate hollow structures are fabricated on surfactant/polymer templates (Zhao and Wang, 2012). After the synthesis, the material can be heated at 500 °C in order to combust the polymer since calcium carbonate is very stable at this temperature (Mantilaka *et al.*, 2014). However, if the polymer is not affective to the final product, no need to put any effort to remove it from the product.

The end use of these hollow materials depends on their particle size, shape (morphology) and volume of hole (Mantilaka *et al.*, 2014). Therefore, there are many efforts on synthesis of various shapes of hollow inorganic materials. The shape of the final particle and the hole depend on the shape of the template. Recently, we, at the physical chemistry research laboratory, Department of Chemistry, University of Peradeniya, have invented and reported a novel nanostructured hollow calcium carbonate material which has morphology, similar to a bone (Mantilaka *et al.*, 2014). So it was named hollow-bone-like calcium carbonate. The SEM and TEM images of the material which has been synthesized are depicted in Figure 03. This structure has been formed by fabricating amorphous and calcite (a crystalline form of calcium carbonate) nanoparticles on anionic polymer/cationic surfactant template. It is expected to use this material for anticancer drug delivery in the future.

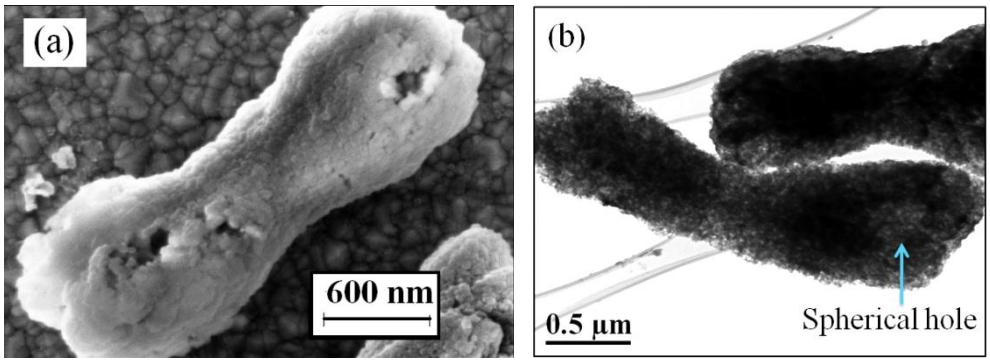

Figure 03: (a) SEM image and (b) TEM image of nanostructured hollow-bone-like calcium carbonate micro-particles which was synthesized at Physical chemistry Research Laboratory, Department of Chemistry, University of Peradeniya

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WHY NATURAL SUBSTANCES ARE IMPORTANT IN INDUSTRIAL EFFLUENT TREATMENT?

Thanuja Kulasooriya
Board of Study in Chemical Sciences

Environmental pollution is a problem that has received a little attention in the developing world. Some of the important contributors of the pollution are increasing population and urbanization which results in an expansion of industrialization. Metal finishing, textile and dyeing, rubber processing are some of the main industries present in Sri Lanka. Since these industries use fresh water for their industrial processes, their industrial effluents must be in an acceptable condition before discharging them in to natural water bodies unless it can cause many adverse effects on human being, animals and also plants. Many industries release their effluents with several pollutants such as heavy metals, sulphates, phosphates, nitrates, dyes etc., which are very harmful to the environment (Priyantha and Bandaranayaka, 2011).

For instance, the adverse effects due to heavy metal contamination on human are metal fume fever, lung cancers, hypertension, cardiovascular diseases, DNA damages, hemolysis, renal and liver failures, allergies and even gradual death. Eutrophication, on the other hand, is a greater problem in the environment due to the high level of phosphorous and nitrates. Higher nitrogen levels in ground water cause the blue baby syndrome and stomach and gastrointestinal cancers. Diarrhea and some laxative effects may result from sulphate contamination.

Considering above facts, Central Environmental Authority (CEA) has enforced standard limits to release industrial effluents to the environment. This is mainly applied for industries which use large amount of water daily for their processes. These standards limits are on basic water quality parameters which gives a measure on the quality of water. pH, Conductivity, Turbidity, Salinity, Total suspended solids (TSS), Chemical oxygen demand (COD), Biological oxygen demand (BOD), nitrate, sulphates, phosphates and heavy metals are some of the key parameters.

In order to remove these substances, physical, chemical and biological treatment methods are used in industries. Many industries use physical and biological treatment methods to treat biodegradable waste while chemical treatment methods are in place to treat industrial effluents containing heavy metals and their compounds and other pollutants. Since chemical coagulants, flocculants and pH controlling agents are in use for the chemical treatment processes, these added chemicals and products formed during the treatment processes may finally affect to the ground water quality resulting in huge environmental problems.

To overcome these issues, many attempts have been made to minimize the above mentioned risks. Natural substances, such as bio-sorbents, coconut shell, brick clay, rice husk, coir dust and saw dust, feldspar and dolomite have been used to remove some heavy metals, anions and dyes from


Brick clay


Rice husk


Saw dust


Coir dust


Feldspar


Dolomite

industrial wastewater (Priyantha and Perera, 2001). Since these environmentally-friendly substances successfully remove pollutants from effluents, such an approach has become highly attractive in comparison to classical methods involving chemicals. Main characteristics which are effective for such removal by these natural sorbents are porosity and their surface charge. Because of above characteristics, most of ions bind to the surface tightly and such bound ions can be removed by using

many desorption techniques. The desorption process is very much important in order to develop these techniques in large scale because the reusing ability of an adsorbent is a key practical issue.

According to literature, it has been reported that these substances can be applied very effectively to remove pollutants from effluents at considerable levels. The efficiencies of these treatment techniques are somewhat similar to other classical treatment techniques.

Natural adsorbent	Pollutant (adsorbate)
Rice Husk	Cd, Cr, Cu, Zn, Pb, Ni
Brick Clay	Cd, Cr, Cu, Zn, Pb, Ni, Phosphate, Dyes
Saw dust	Cd, Cr, Cu, Zn, Pb, Ni, Sulphate
Dolomite	Sulphate
Feldspar	Sulphate, Phosphate, Dyes

Since these techniques are still in experimental stage, it will take some time to utilize these approaches in real treatment systems. The most of the listed adsorbents are waste materials and readily available in the environment and treatment plants utilizing said substances will be environmentally friendly. The main disadvantage of this method is difficulty in producing large quantities of adsorbents for industries. Therefore, in real application, it is necessary to find a way to preserve the adsorbent materials whenever it is necessary to be used.

Therefore, if these methods can be adopted even in combination with other treatment technologies, it will help to keep the longevity of our fresh environment for future generations as well.

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OVERVIEW TO HYDROXYAPATITE NANOPARTICLES AND THEIR APPLICATIONS

W.P.S.L.Wijesinghe
Board of Study Chemical Sciences

Hydroxyapatite (HA) is a naturally occurring phosphate mineral with the formula,$Ca_5(PO_4)_3(OH)$. However, the crystal unit cell of HA contains two entities and hence generally written as $(Ca_{10}(PO_4)(OH)_2)$.The OH^- ions of HA crystal can be replaced by fluoride, chloride or carbonate, producing fluorapatite or chlorapatite. It crystallizes in the hexagonal crystal system with (a = 9.41 A, b = 6.88 A, z = 2) unit cell parameters. Crystal structure of HA clearly indicate in Figure 01. Pure HA powder is white in color and naturally occurring apatite has different colors such as brown, yellow, or green colourations due to the incorporation of the various metal ions into the HA crystal lattice.

HA nanoparticles are the major and most abundant material in human bones and teeth. As a result, synthetic HA nanoparticles that mimic natural HA are extensively synthesized to repair and substitute human bones. The composition, grain size, large surface area-to-volume ratio, and crystallinity of synthetic HA nanoparticles are very similar to biological apatite. Hence, synthetic HA nanoparticles have exceptional biocompatibility and superior bioactivities such as osteoconduction and osteointegration. HA nanoparticles are mostly used as a coating material in manufacture of biocompatible metallic implants since it is able to control the removal of metallic ions from the metallic implant to the human body. Furthermore, HA nanoparticles can easily be combined with biodegradable and non-degradable polymers, so HA nanoparticles are used to prepare large number of polymer nanocomposites such as collagen/HA,Poly(lacticacid)/collagen/HA, alginates/collagen/HA, chitozan/HA, gelatine/HA, Poly(caprolactone)/HA, Poly(lactic acid)/HA, Poly(ethylene)/HA, Poly(urethane)/HA, Poly(tetrafluoroethylene)/HA, Poly(methyl methacrylate)/HA and so on. These nanocomposites are used as drug delivery systems as well as to prepare bone cement for biomedical applications. Therefore, HA nanoparticles are one of the highest value in biomedical field (Murugan and Ramakrishna, 2005).

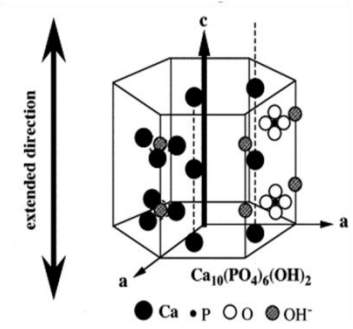

Figure 01- Crystal structure of the Hydroxyapatite

There are a large number of available methods to synthesize HA nanoparticles including mechanochemical synthesis, electrochemical deposition, sol-gel technique, chemical precipitation from aqueous solutions, combustion and hydrothermal methods. Furthermore, various morphologies of HA have been recorded by different researches and it may vary with their preparation methods as given in Table 01. Needle-like and spherical shapes of HA nanoparticles are the most common applicable morphologies of HA (Sadat-Shojai *et al*., 2013).

Table 1. Different shapes of HA nano-particles and their appropriate preparation methods.

Shapes of HA nano-particles	Morphology	Preparation methods*
	irregular, formless, sphere	ss, mch, cc, hl, sg, hth, em, sch, ht, bs, cp
	sphere, microsphere, nanosphere, ball	mch, cc, sg, hth, em, sch, ht, bs, cp
	rod, needle,	cc, hl, hth, bs, cp

	plate, flake, sheet	cc, hl, hth, bs, cp
	leaf, flake, sheet, plate	hth, em, bs, cp
	flower	cc, hl, cp
	Dumbbell	hth, cp

We, at physical chemistry research laboratory, Department of chemistry, University of Peradeniya have synthesized pure HA nanoparticles with needle-like and spherical shapes (Figure 02) using dolomite and apatite (at Eppawala, Sri Lanka) as raw-materials with novel, simple and economical methods. Those isolated HA nanoparticles can be used in Biomedical applications.

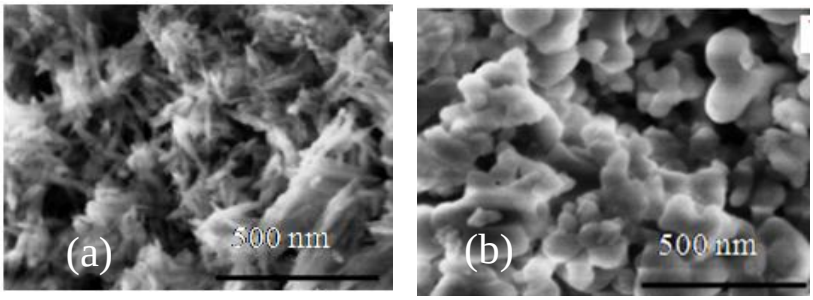

Figure 02. SEM images of (a) Needle-like HA nanoparticles (b) spherical shape HA nanoparticles.

Where, ss: solid-state synthesis, mch: mechanochemical method, cc: conventional chemical precipitation, hl: hydrolysis method, sg: sol–gel method, hth: hydrothermal method, em: emulsion method, sch: sonochemical method, ht: high-temperature processes, bs: synthesis from biogenic sources, cp: combination procedures.

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AUSTROEUPATORIUM INULIFOLIUM INVASION IN KNUCKLES CONSERVATION AREA

Inoka Piyasinghe
Board of Study in Earth Sciences

Invasive plants

Invasive species pose a growing problem around the world, both ecologically and economically. Invasions can influence the native flora negatively. Invasive plants also know to possess many physiological and morphological traits that help them to invade successfully in introduced habitats. Some of these traits include their superior competitive ability over native flora, their high reproductive ability and their potential to colonize on disturbed areas. Invasive plants can spread into new habitats already occupied by native flora and displace them. Therefore, intentional and/or unintentional transport of plants to new regions has become a serious threat the biodiversity and ecosystem functions. Human activities have accelerated long-distance transport of organisms, frequency of colonization, and establishment and invasion of non-native populations. Most of the impacts of invasive plants are considered as negative but there are reports of positive impacts especially on degraded habitats.

Austroeupatorium inulifolium

Taxonomic name: *Austroeupatorium inulifolium* (Kunth) R. M. King & H. Rob
Synonyms: *Austroeupatorium inulaefolium* (H.B.K.) R. M. King & H. Rob.
Eupatorium inulifolium Kunth
Habit: Herb/shrub
Habitats: Agricultural fields, fallow fields, waste lands and roadsides etc.

Habit and the habitat of *Austroeupatorium inulifolium*

General impacts:

Austroeupatorium inulifolium is listed as an "agricultural and environmental weed" in the Global Compendium of Weeds, (2008). It is a serious weed in the Philippines where it forms very dense thickets in rubber, tea and rosella plantations, upland rice plantations and in clearings of secondary forests (Waterhouse and Mitchell, 1998). In Sri Lanka, this plant has been identified as an invasive alien plant recently. For the last few years, *A. inulifoium* has spread into the Knuckles Conservation Area (KCA) and has invaded many ecosystems such as grasslands, plantations and roadsides.

Invasion of *Austroeupatorium* in Knuckles conservation area

KCA is a unique ecosystem in Sri Lanka, and consists of varying land use patterns providing a refuge for many endemic and threatened floral and faunal species. *Austroeupatorium inulifolium* has been rapidly invaded in and around KCA during the past few years. Out of many land use types in KCA, *Cymbopogon* dominated grasslands are the most vulnerable for this invasion. *Austroeupatorium* can also be seen in other land use types such as roadsides, *Pinus* undergrowth and forest-grassland edges. It is important to improve the basic ecological understanding of these invasions in order to

reverse or mitigate their often devastating effects. Understanding the invasion process and basic attributes correlated with invasibility can enhance the strategic planning processes for early detection, management and mitigation of these invasive species effectively.

Research findings

A preliminary studies conducted by Haluwana and Madawala in 2013 have shown that *Austroeupatorium* invasion has a facilitative effect on the tree seedling establishments on highly degraded grasslands in the Knuckles Conservation Area (KCA), and suggested that this positive effect possibly due to enhanced edaphic and micro-climatic parameters. Further experiments on *A. inulifolium* have shown that this plant is physiologically and morphologically more plastic than other co-habitating plants, which is considered as an important trait possess by invasive species to perform well under harsh conditions. This ability of *Austroeupatorium* may be the driving force behind high invasion rates into *Cymbopogon* dominated grasslands in the KCA (Piyasinghe *et al*., 2010). Studies also revealed high quality and litter inputs, and decomposition rates of *Austroeupatorium* litter that may leads to changes in the soil nutrient pools and their cycling processes over time (Piyasinghe *et al*., 2013).

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POTENTIAL FOR DIRECT UTILIZATION OF GEOTHERMAL ENERGY IN SRI LANKA

S.M.P.G.S. Kumara
Board of Study in Earth Science

Geothermal energy is the natural heat of the earth and is available as an indigenous source of energy in all countries over the world. At present, geothermal energy is being used primarily for the production of electric power, but it can be utilized in other forms, such as space heating and industrial heating. The geothermal energy may be of great value in the economy of many nations seeking development of alternative energy sources and conservation of fossil and nuclear fuels.

In Sri Lanka, Geothermal Energy has been manifested as 10 low enthalpy thermal springs (35 to 61 C^0) along a narrow belt which runs approximately parallel to the Highland complex (HC) and Vijayan complex (VC) lithological boundary (Figure 01). These springs are not being used for any economic purpose while some have been used for recreational purposes.

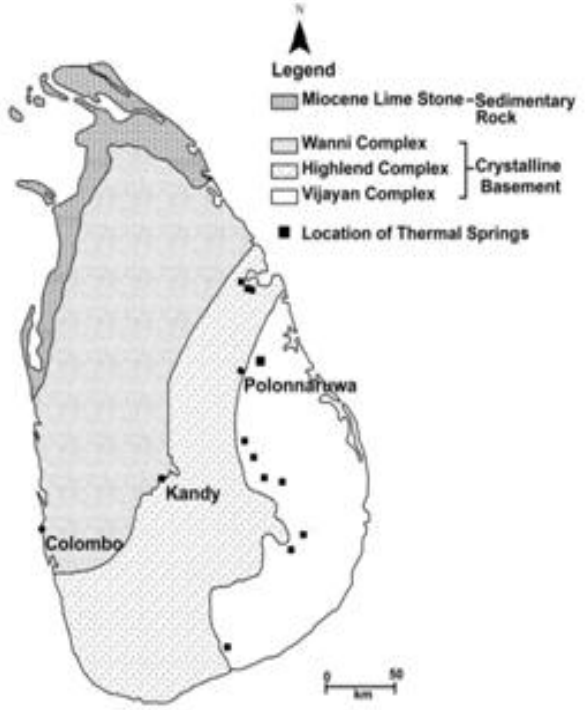

Figure 01: Location of thermal springs Sri Lanka

The energy demand of Sri Lanka is increasing day by day due to growth of industrial and household requirements of energy. According to statistics of sustainable energy authority, Sri Lankan total energy demand in 2012 is 38.3 PJ. Huge amount of fossil fuel, biomass and hydropower have been used for catering this energy consumptions. Involvement of these energy sources has been also made considerable contribution to environmental pollution in Sri Lanka. Hence, environmental friendly, pollution free, renewable energy is very important.

Geothermal energy can either be utilized for electricity generation or for direct heat utilization. Geothermometry studies of Sri Lankan thermal springs indicate that the reservoir fluids are in the low to medium enthalpy range (Chandrajith *et al.*, 2013; Disanayake and Jayasena, 1988) which means that the resource is best suited for direct use applications. This article aims to discuss possible direct application of the geothermal energy sources of Sri Lanka.

Direct application of geothermal energy can involve a wide variety of end uses, and it involves mostly existing technology and straightforward engineering. When the electricity is produced

from geothermal energy with direct utilization, there are several advantages such as much higher energy efficiency (direct use 50 – 70% and electric power 5 - 20% for conventional geothermal electric plants), generally shorter development time, and normally much less capital investment (Lindal, 1973). Direct application is, however, much more site specific for the market, as steam and hot water is rarely transported long distances from the geothermal site due to rapid heat loss during the transportation.

Potential for direct use of Sri Lankan geothermal fields

The areas around geothermal manifestations have a dry climate and the major economic activity in the areas is agriculture. It is also a popular tourist destination because of the wildlife and beach (specially Trincomale to Hambanthota). These sectors can be benefited immensely from the geothermal energy through direct utilization. The possible applications include drying of agricultural products (cereal), sugar processing, paper mill operation, cold storage and in recreational facilities such as warm pools, saunas and steam baths.

Steaming and drying of agricultural products

The geothermal manifestations have been located in Trincomale, Polonnaruwa, Monaragala and Hambanthota districts. The area is extensively agricultural. Rice, maize, soya, peanut, sugar cane, banana, and same *Cucurbitaceae* family crops have been cultivated. Rice and cereal production industries have been used thermal energy for steaming and drying. A part of energy consumption of this production can be supplied using these geothermal energy systems.

Sugar processing

Interesting field for the application of geothermal energy is found in sugar processing. Cane sugar production involves two process steps, each requiring considerable amounts of steam; first the production of raw sugar and then its refinement. The geothermal heat energy can be used for evaporation in multiple effect evaporators. Another interesting and closely related field is found with fermentation processes based on molasses. Among the products are ethyl alcohol, butanol, acetone and citric acid, all of which may benefit by the availability of liberal amounts of steam. It is reported that natural heat is already used in several countries for brewing and distillation. Cane cultivation in the area can be used as a cost effective and easy process to manufacture sugar or other valuable products using this geothermal energy.

Pulp processing for paper production and timber seasoning

There are two principal methods for processing essentially pure cellulose pulps out of wood, namely the Kraft and the sulphite process. The process is essentially chipping of the wood, digesting the chips by steam in the presence of chemicals, and separation cellulose from the digested wood by washing, drying etc (Shreve, 1956; Smith, 1970). This process takes substantial amounts of steam in the general process and drying operation. Maize and rice hay can be used to produce paper using this method followed by geothermal energy. Timber seasoning by natural heat appears to be common (Burrows, 1970; Lindal, 1964). Geothermal energy can be used for veneer fabrication, and a number of other seasoning operations of timber beneficially (Burrows, 1970).

Cold Storage

Cold storage of fresh vegetables, fruits, meat and beverages can be achieved by the use of absorption chillers which utilize hot water as energy source. The most appropriate absorption chilling machine for this operation uses a mixture of water and ammonia as the working fluid. Geothermal energy can be supported to operate the cooling pump. Use of this technique can facilitate the storage of fresh agricultural products manufactured in the areas of thermal springs.

Recreational and health applications

Hot springs and warm mineral springs have been used for recreational and health purposes for many centuries, even in Sri Lanka. There are records of many geothermally heated swimming pools, mineral baths, mud baths, steam baths and specially organized recreational centers from several countries. Although thermal springs have been used for above purposes in Sri Lanka from ancient times they have to be developed according to the modern requirements. In recent years tourism impressively increased in thermal spring areas and such places have become more accessible to people. Therefore additional infrastructures such as hotels, recreational facilities have to be developed for better tourist attractions on such places.

Summary

Convective heat loss from all outflow zones associated with Sri Lankan thermal springs can be utilized in drying of agricultural products (cereal), fish and sea food processing, sugar processing, paper mill operation, cold storage and recreational facilities. Geothermal energy can therefore be used to improve the livelihood of the local communities in Sri Lanka. Most of these applications are related to agricultural, industrial and tourism activities. Use of geothermal energy in such sectors will replace the need for utilization of expensive and environmentally unfriendly fossil fuels. Such applications will be effective sources of employment which will lead to poverty elevation.

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COCONUT WATER: WILL IT BE A GRAND REFRESHMENT?

Sampath Wickramasooriya
Board of Study in Chemical Sciences

Most of the common drinks available in the market have processed with artificial chemicals. Some of those chemicals such as preservatives, flavors are harmful to human health. Researchers have proved the kinds of toxic effects of such chemicals on human health. Under these circumstances, scientists have diverted their vision toward food safety, preservation and processing with environmental friendly methods. Naturally available coconut water is a good substitute for artificial drinks.

Composition and nutrients of coconut water

Tropical countries like Southeast Asia , Pacific countries, Caribbean, Africa and Brazilian coast are the main producers of the fresh coconut water from the inside of the young coconuts. King coconut and normal coconut water are the main categorized species while king coconut water is sweeter than normal coconut water. Fresh coconut water is harvested from the tree at the young stage of coconut while pH exits between 4.0 to 5.0. This young coconut water has been popular among the world as natural drink. Preservative methods are being used to preserve samples for 1-2 months which are not harmful to human health. Nutrition and composition of coconut water have gained interest due to its nutrients and its nature of energetic refreshment. The presence of vitamins, minerals, antioxidants, amino acids, enzymes, growth factors, and other nutrients gives an additional value to coconut water (Freelance, 2014).

Nutrition Facts of Coconut Water: (USDA Nutrient Database)- Value for 100 g

Energy	354 (cal)
Sugars	6.23
Dietary fiber	9.00
Carbohydrates	24.23
Water	47.00
Protein	3.33
Fat	33.49
Magnesium	32.00
Zinc	1.10
Iron	2.43
Potassium	356.00
Calcium	14.00
Vitamin C	3.30

Healthiest effect

Coconut water is being used as sport and natural drink due to its high content of minerals such as Potassium(K) and Sodium(Na). Some research has revealed that electrolyte level of the coconut water is equal to that of human body. Furthermore, research shows that coconut water can improve blood circulation, lower elevated blood pressure and reduce the risk of heart attacks and strokes. Cholesterol free coconut water gets a priority as a health drink when compared with other drinks. Medical researchers have revealed that coconut water is very effective to dissolve kidney stones and is able to clean urinary and reproductive systems (Lee, 2014). It is believed that coconut water can be substituted for saline water.

Why don't you adapt to such valuable drink rather than poisonous artificial drink? Don't be late, as soon as move your life towards the healthiest.

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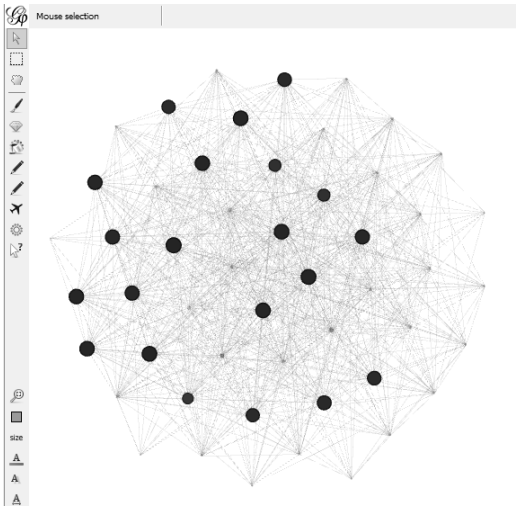
APPLYING VISUAL ANALYTICS IN SOCIAL NETWORK ANALYSIS AND LARGE SCALE DATA

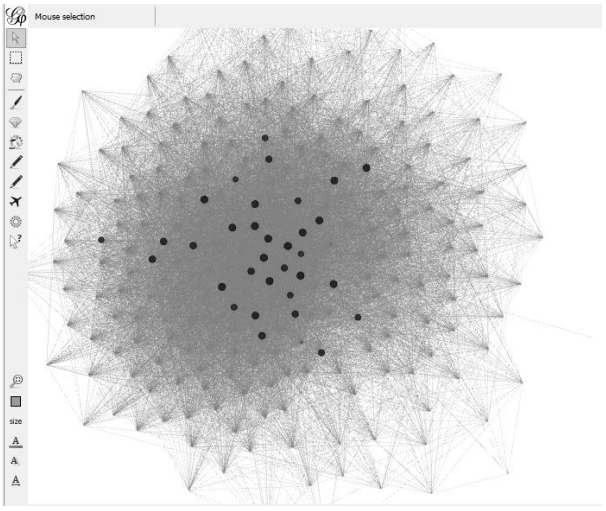
Akalanka Galappaththi
Board of Study in Statistics and Computer Science

We are living in the world where information found in structured or unstructured way and the information or data is in large scale. Generally we call them "Big Data". Analysing big data is a tedious task which consumes time. Time is a big hurdle in data analysis where analysts required to produce results within an acceptable time period. Compare to text based analysis visual techniques speed up the process since the human cognition can identify the patterns in visualized data much easily.

In the context of social network analysis, the visualizing tools are categorized into different generations according to their characteristics. First generation tools only provide a visual representation of entities in the network where network is drawn manually. Anacapa map is an example for the first generation tool. The paper published by Valid E. Krebs in 2001 at Connections 24-3 contains information of hijackers of 9/11 attack (Krebs, 2001). It is clearly observable that visualizing information is very much helpful in detecting relationships among patterns compare to textual presentation. Second generation tools have the ability to create the network automatically from data stored in a spread sheet file or a text file. Analyst's Notebook, Netmap and XANALYS link explorer are some of the tools in this category (Xu and Chen, 2005). However, still they do not provide analytical capabilities. Third generation tools provide the capability of analysing social network data to identify relational and positional information of entities. Relational analysis can find entities with higher degree, node which lies between geodesies of nodes and node which has the shortest path to many other nodes. Such information can reveal the importance of a particular person in a network for its logistic viability. Positional analysis finds entities which has similarities according to their features and associations between other nodes in the network. Hence possible substitute characters in the network can be identified.



A user interaction of a group in facebook with 51 nodes and 802 edges using Gephi tool



A user interaction of a group in facebook with 238 nodes and 12620 edges using Gephi tool

Visualizing social network data can provide deep insight of people in the network and rolesthey play in the network compared to simple statistical reasoning. A graphical representation of entities in the network and their interactions as a graph with nodes and edges is very convenient to the human. It provides the capability of analysing level of interaction by visualizing weights on edges, relative position of nodes to represent central members of network with many links to other nodes, nodes which lay between shortest path of other nodes and node which starts shortest paths to other nodes. First generation tools are practical in drawing relatively small networks. When drawing large scale complex networkssuch asfacebook, twitter and linkedin it becomes impractical. Further network

structure is dynamic in social networks due to its growing or shrinking nature. Each small change requires tracking to understand the network structure since they change the cluster size and centrality measurements.

One of the challenges in graph creation in network analysis is the layout mapping. An efficient placement of nodes provides meaningful visualization. Force-directed approach, fast multipole multilevel mode and graphic drawing with intelligent placement are some algorithms used to layout static graphs (Ma and Muelder, 2013). Space filling curve method can represent clusters in a static graph. Clusters contain nodes with similar features.

Visualizing dynamic network suffers from the trade-off between stability and layout quality. One common method used is the animating the changes of dynamic graph which results appearance or disappearance of nodes and changes in placement of nodes. Another method is placing vertices on parallel vertical lines with directed edges from left to right. The changes to graph displayed in time step graph where two consecutive vertical lines show the time step. Incremental clustering based layout method and global clustering based layout method provide quality layout and stable network in each time step. As for the limitations, incremental clustering doesn't guarantee that the layout is the ideal compared to initial cluster while global clustering has a large computational burden (Ma and Muelder, 2013).

The whole purpose of applying visual analytics in social network analysis is to provide a means of analysis. Hence semantics of the network data need to be considered. It is much more convenient to show only relevant entities and their related association with other nodes rather than displaying the full network. For example, association weight can be used as negatively related to the distance of the edge. This will result some nodes in tightly associated while others are associated loosely. Further applying colours accordingly to represent links between group members and mix of colours to represent links between different group members will provide more semantics to the user.

With the overwhelming large amount of data with large scales in social networks, use of visual analytics has more advantagesin analysing them. Depends on the dynamic nature of the networks it is a very difficult task to find efficient method for creating network layout preserving the stability of the network over time. The future of this field is to combine different methods for dynamic network visualization to eliminate the disadvantages of each method. Clustering methods are heavily used in the domain to identify structural and feature level similarities of entities to create layout to represent semantics of the network. Centrality measure plays a major role finding importance of entities in the network and their impact to other entities and to the network overall. Visualizing these features provides the means of analysis to the analyst of the network.

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GIS IN CRIME ANALYSIS

M.A.P.Chamikara
Board of Study in Statistics and Computer Science

Figure 01: Crime Mapping

Crime data collection and dissemination is a cyclical and an on-going process due to the increased frequency of crime incidences in all around the world. Crime information has become vital for conducting crime analysis. The vast geographical diversity and the cognitive biases of the criminals have made crime analysisa very difficult task (Giles and Brian, 2011). To address this complex issue, many computer based methods are being practiced in police departments all over the world. In crime analysis, both qualitative and quantitative techniques are used to analyze crime data in a more effective manner (Chen *et al.,* 2004). Qualitative data and analytical techniques refer to non-numerical data analysis where it helps to discover underlying meanings and patterns. Quantitative analysis is based on data primarily in numerical or categorical format. Quantitative data is used primarily in the sense of statistical analysis. Crime analysis employs both Qualitative and Quantitative analysis of data and techniques which depend on the analytical and practical need.

Figure 02: Crime Hotspot Detection

GIS (Geographical Information Systems) which is one of the very effective quantitative data analysis methods which have become one of the best technologies used nowadays by these security institutions to improve the crime investigation quality, because maps have the power of offering crime analysts the crime related issues in a notion of graphical mechanism. GIS facilitates the modeling of the workflow of a crime and captures its best practices. The location where crimes or activities occur and the relationship of those places to one another and to other information is an important factor in crime analysis (Chamikara *et al.,* 2012). It is not only important where a crime takes place but also the characteristics of those places and the environment in which the crime occurs. Thus, examination of spatial data such as streets networks, parcel information, orthophotographs, schoollocations, business and residential zoning, among others, is imperative for effective crime analysis. Simple maps that display the locations where crimes or concentrations of crimes have occurred can be used to help direct patrols to place where they are most needed. Policy makers in police departments might use more complex maps to observe trends in criminal activities, and maps may prove invaluable in solving criminal cases. Digital maps are the quickest means of visualizing the entire crime scenario. The locations of crime events, arrests, etc. can be routinely displayed on maps. This provides an easy method of viewing activities in an area rather than searching through a list of events. Maps can also be used to convey more than one type of information at a time. Crime locations can be symbolized according to the day of week, type of crime, modus operandi (a particular suspect's method of operation when committing a crime) or frequency (Agrawal *et al.,* 1993).

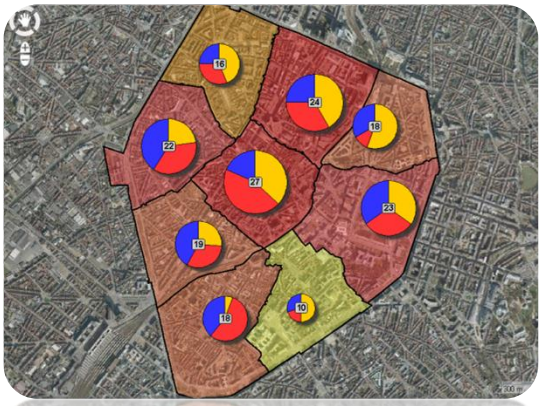

Figure 03: Geographical Crime Comparison

In addition, mapping and GIS can support community and problem oriented policing. Mapping and GIS can show detailed relationships between the crime, victim, and the offender. Some other very important aspects of mapping and GIS are, showing of demographic and population changes, assisting in resource allocation, integrating data from community and government sources, providing effective communication tools. Figure 01, Figure 02, and Figure 03 depict the graphical interpretations of the three applications, crime mapping, crime hotspot detection, geographical crime comparison respectively. GIS aids crime analysis also byidentifying and highlighting suspicious incidents and events that may require further investigation. Supporting patterns and trend analysis across multiple jurisdictions, enhancing the implementation of various policing methodologies to reduce overall crime and disorder, and integrating traditional and non-traditional law enforcement data to improve overall analysis are few other very important applications of GIS which aids the crime analysis process in a drastic manner. One other very important facet of GIS is educating the public with visual information to clarify crime concerns and enlist community action, providing tools and techniques to capture crime series and forecast future crime occurrences (Koperski and Han, 1995).

Primary goal of law enforcement is anyhow to prevent crimes through the methods other than apprehension. Therefore, GIS lends itself particularly well to assist for crime analysts towards the need of crime prevention of many security institutions.

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FRACTALS –HIDDEN DIMENSIONS OF NATURE...

A.A.C.A. Jayathilake
Board of Study in Statistics and Computer Science

The French mathematician Benoit B. Mandelbrot first coined the term fractal in 1975. He derived the word from the Latin fractus, which means "broken", or "irregular and fragmented". In fact, the birth of fractal geometry is usually traced to Mandelbrot and the 1977 publication of his seminal book The Fractal Geometry of Nature (Fractal Geometry, 2014). Mandelbrot claimed that classical Euclidean geometry was inadequate at describing many natural objects such as clouds, mountains, coastlines and trees. So he conceived and developed fractal geometry. There are two main groups of fractals: linear and nonlinear. The latter are typified by the popular Mandelbrot set and Julia sets, which are fractals of the complex plane.

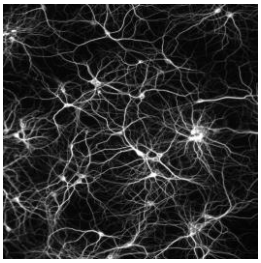

Figure 01: Neurons

A fractal is a never-ending pattern. Fractals are infinitely complex patterns that are self-similar across different scales. They are created by repeating a simple process over and over in an ongoing feedback loop. Driven by recursion, fractals are images of dynamic systems – the pictures of Chaos (Figure 02).

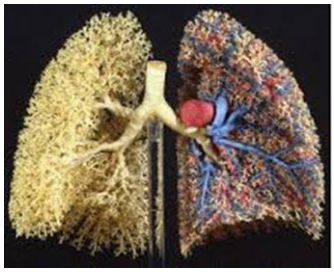

Figure 02: Fractals in Physiology

Geometrically, they exist in between our familiar dimensions. Fractal patterns are extremely familiar, since nature is full of fractals. For instance: trees, rivers, coastlines, mountains, clouds, seashells, hurricanes, etc. Abstract fractals – such as the Mandelbrot Set – can be generated by a computer calculating a simple equation over and over.

Fractals are found all over nature, spanning a huge range of scales. We find the same patterns again and again, from the tiny branching of our blood vessels and neurons (Figure 01) to the branching of trees, lightning bolts, and river networks. Regardless of scale, these patterns are all formed by repeating a simple branching process. A fractal is a picture that tells the story of the process that created it.

Figure 03: Nautilus shells

The spiral (Figure 03) is another extremely common fractal in nature, found over a huge range of scales. Biological spirals are found in the plant and animal kingdoms, and non-living spirals are found in the turbulent swirling of fluids and in the pattern of star formation in galaxies.

All fractals are formed by simple repetition, and combining expansion and rotation is enough to generate the spiral.

Figure 04: The Sierpinski Triangle

Purely geometric fractals can be made by repeating a simple process.

The Sierpinski Triangle (Serpinski Triangle (2014)) is made by repeatedly removing the middle triangle from the prior generation. The number of coloured triangles increases by a factor of 3 each step, 1,3,9,27,81,243,729, etc.(Figure 04 and 05)

Figure 05: The extended Sierpinski Triangle

The Koch Curve (Koch curve, 2014) is made by repeatedly replacing each segment of a generator shape with a smaller copy of the generator(Figure 06). At each step, or iteration, the total

length of the curve gets longer, eventually approaching infinity. Much like a coastline, the length of the curve increases the more closely you measure it.

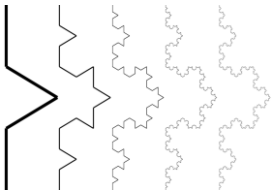

Figure 06: The Koch Curve

Fractals have more and more applications in science.

Astronomy-Fractals may be revolutionize the way that the universe is seen. Cosmologists usually assume that matter is spread uniformly across space. But observation shows that this is not true. Astronomers agree with that assumption on "small" scales, but most of them think that the universe is smooth at very large scales. However, a dissident group of scientists claims that the structure of the universe is fractal at all scales. This led to the surprising result that galaxy correlations are fractal and not homogeneous up to the limits of the available catalogues.

Nature-Take a tree, for example. Pick a particular branch and study it closely. Choose a bundle of leaves on that branch. To chaologists, all three of the objects described the tree, the branch, and the leaves are identical. To many, the word chaos suggests randomness, unpredictability and perhaps even messiness. Chaos is actually very organized and follows certain patterns. The problem arises in finding these elusive and intricate patterns. One purpose of studying chaos through fractals is to predict patterns in dynamical systems that on the surface seem unpredictable. Fractals are used to model soil erosion and to analyze seismic patterns as well. Seeing that so many facets of mother nature exhibit fractal properties, maybe the whole world around us is a fractal after all!

Computer science-The most useful usage of fractals in computer science is the fractal image compression. This kind of compression uses the fact that the real world is well described by fractal geometry. By this way, images are compressed much more than by usual ways (eg: JPEG or GIF file formats). Another advantage of fractal compression is that when the picture is enlarged, there is no pixelisation. The picture seems very often better when its size is increased.

Fluid mechanics-The study of turbulence in flows is very adapted to fractals. Turbulent flows are chaotic and very difficult to model correctly. A fractal representation of them helps engineers and physicists to better understand complex flows. Flames can also be simulated. Porous media have a very complex geometry and are well represented by fractal.This is actually used in petroleum science.

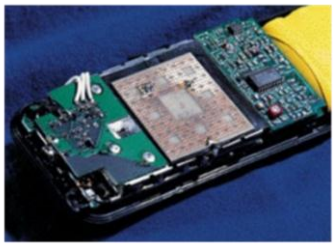

Figure 07: Fractal-shaped antennae

Telecommunications-A new application is fractal-shaped antennae (Figure 07) that reduce greatly the size and the weight of the antennas . The benefits depend on the fractal applied, frequency of interest, and so on.

Surface physics- Fractals are used to describe the roughness of surfaces. A rough surface is characterized by a combination of two different fractals.

Medicine- Biosensor interactions (Figure 08) can be studied by using fractals.

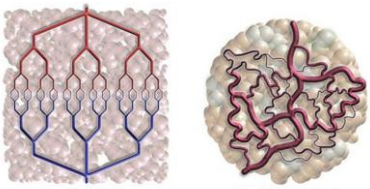

Figure 08: Biosensor interactions

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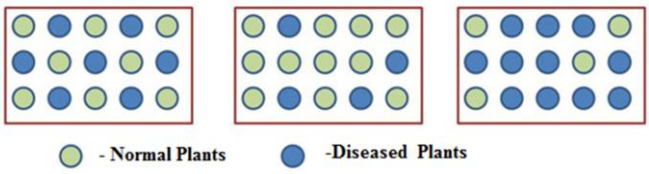
A NEW BINOMIAL MIXTURE MODEL FOR MODELING DISEASE INCIDENCE DATA

C. Manoj
Board of Study in Statistics and Computer Science

Binomial outcome data are commonly encountered in many ecological studies. Examples include "plant disease incidence data", "plant species richness data", "capture-recapture data "andmany others. Understanding the ecological characteristics of such data is an important focusing ecological studies. However, it is observed that the Binomial distribution often fails to model this data due to "overdispersion".

In such situations, the class of Binomial mixture distributions can be used to well describe the binomial outcome data. Conditional on the success probability p, suppose Y follows a Binomial distribution given by $Bin(n, P)$, which is denoted by $Y|p \sim Bin(n, P)$. Unconditional probability mass function of the Y can be obtained by evaluating the well-known integral, $P_Y(y) = \int P_{Y|p}(y) f_P(p|\Theta) dp$ for $y = 0,1, \ldots n$ and Θ is the parameter space of the mixing distribution $f_P(p|\Theta)$. The Beta-Binomial distribution is the classical member of this class of distributions. Even though several alternative and generalized Binomial mixtures distributions have been proposed in statistical methodological literature, the applications of these distributions are not yet discussed in a wide range including "Plant Pathology" studies. The major reason for this is that the likelihoods of the recently developed Binomial mixture distributions are complex and hence not much easier to handle compared to that of Beta-Binomial distribution. However, due to the availability of very flexible computer software packages, this is not a big problem nowadays. Here we focus on recently developed McDonald Generalized Beta-Binomial (McGBB) to model these types of data and comparisons are done with classical Beta-Binomial (BB) distribution to model the frequency distributions and to evaluate ecological characteristics. Similarities and Improvements of the two Binomial mixture distributions are discussed.



A Binomial experimental setup of plant disease incidence data.


TSWV infected tomato plants

Plant disease incidence data can be characterized by the number of diseased plants(Y) out of total number(n) of plants available in a sample unit. In order to model this type of data using the Binomial distribution, the location of a diseased plant should be independent of the location of the other diseased plant and the probability of being diseased should remain constant from plant to plant. But, by its nature, these assumptions are often violated in practice.

Here we consider a simulated realistic data. An experimental tomato field is divided into N=500 quadrats with each consisting n=5 plants. The number of tomato spotted wilt virus (TSWV) infected tomato plants out of n=5 in each of the quadrats were recorded in order to study the mean disease incidence and the degree of disease aggregation. The data in the form of the frequencies are given in Table 1.


Fruit and Leaf Symptoms of TSWV

Here, we briefly outline the two Binomial mixture distributions. Theoretical properties of the distributions are not presented here.

- **Beta-Binomial Distribution**

$$P_{BB}(y) = \binom{n}{y} \frac{B(a+y, n+b-y)}{B(a,b)} \text{for} y = 0,1, \ldots \text{n and } a, b > 0.$$

- **McDonald Generalized Beta-Binomial distribution** (Manoj, Wijekoon and Yapa.,2013)

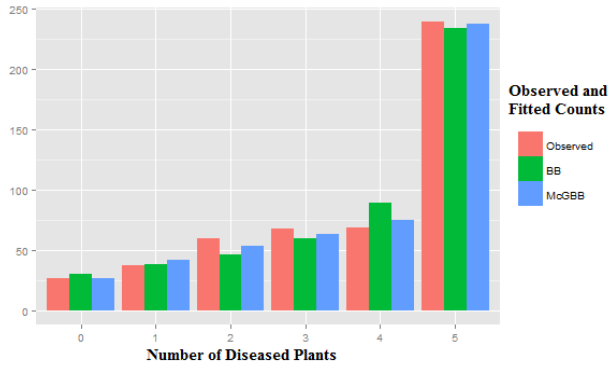
$$P_{McGBB}(y; n, \alpha, \beta, \gamma) = \binom{n}{y} \frac{1}{B(\alpha,\beta)} \sum_{j=0}^{n-y} (-1)^j \binom{n-y}{j} B\left(\frac{y}{\gamma} + \alpha + \frac{j}{\gamma}, \beta\right) \text{for } y = 0,1, \ldots n$$

and $\alpha, \beta, \gamma > 0$

Maximum Likelihood Estimates of the unknown parameters of the mixture models are obtained by constructing the log-likelihood functions of the models and minimizing the negative log-likelihood function with respect to the parameter space of the particular distribution. R programs are written for estimations and comparisons.

Table 1: Modeling Results of TSWV Disease Incidence Data

Number of Diseased Plants	0	1	2	3	4	5	Total	χ^2(DF)	p-value
Observed	27	37	60	68	69	239	500	-	-
BB	30.62	38.06	46.96	60.76	89.47	234.13	500	9.7252 (3)	2.1067 (2)
McGBB	26.91	41.9	53.58	63.72	74.98	238.91	500	0.0210	0.3487



Graphical Comparison of Observed and Fitted Frequencies

Table 2: Evaluated Ecological Characteristics of TSWV Disease Incidence Data

Ecological Characteristics	BB	McGBB
Mean Disease Incidence, $\hat{\pi}_D$	0.7371	0.7339
Degree of Disease aggregation, $\hat{\rho}_D$	0.4032	0.4002

Pearson's Chi-Square goodness of fit test results indicate that McGBB (p-value=0.3487) is a better fitted model to model the plant disease distribution presented above. The BB model (p-value=0.0210) is significantly rejected to model this data based on the Chi-Square goodness of fit test. Furthermore, Analysis of Deviance (ANODEV) results indicate that the classical BB model is rejected in favour of McGBB model (p-value=0.0055). Although McGBB model provides better fit than BB model, both models result similar ecological conclusions. From the Table 2, it can be interpreted that a quite high mean diseases incidence ($\hat{\pi}_D \approx 0.73$) and a moderate degree of disease aggregation ($\hat{\rho}_D \approx 0.4$)exists in TSWV infected tomato plants in experimental fields.

A comparison study is presented for the recently developed Binomial mixture distribution, McDonald Generalized Beta-Binomial with the classical Beta-Binomial distribution for the analysis of "plant disease incidence data" which arises in many plant pathology studies. Even though Beta-Binomial model still stands as an adequate model in modeling such data, the need of an improved model in analyzing ecological data is recognized. An important point which should be noted from this study is, even though more complex models result significant improvements in modeling frequency distributions, they provide similar ecological inferences. Simulations study results do provide guidelines in identifying the parameter combinations for which a particular model performs well compared to other models. Interested readers may refer to the reference cited below for a detailed discussion on identifying a better model based on parameters combinations.

Acknowledgment

A special acknowledgement goes to the research supervisors Prof. (Mrs.) Pushpa Wijekoon and Dr. Roshan D. Yapa, Department of Statistics and Computer Science, University of Peradeniya.

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THE BEST PROTECTION IS EARLY DETECTION

R.R. Nanayakkara
Board of Study in Statistics and Computer Science

Breast cancer is the most common, most frequently diagnosed cancer type and the second major cause of cancer death in women worldwide (Ahmedin *et al*., 2011). Every one in eight women will develop breast cancer in their lifetime and for men it is about 1 in 1,000. According to Sri Lankan Cancer Registry 2005, breast cancers are the highest cancer type (25.4%) reported in Sri Lankan women.

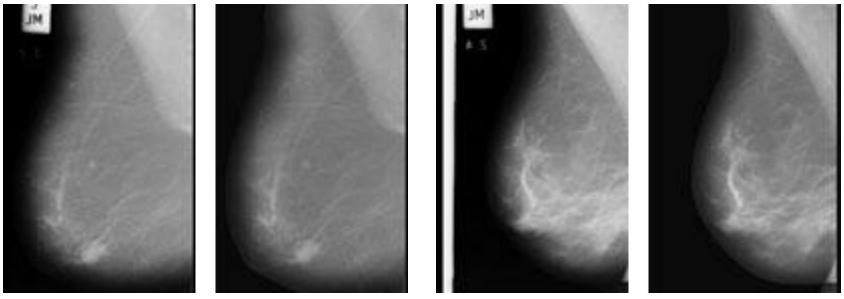
Breast cancer screening looks for signs of cancer before a woman has symptoms. Screening can help find breast cancer early, when the chance of successful treatment is best. American cancer society recommended to have an annual mammogram women who are elder than 40 years and have family history or high breast cancer risk factors.

Mammography is the most effective method of detecting cancer at an early stage, before the woman or a physician can feel it. Stellate lesion, mass and microcalcifications are the most common mammographic sign used for detection of breast cancers (Breast Cancer, 2014).

Retrospective studies have shown that the estimated sensitivity of radiologists in breast cancer screening is only about 75% (Bird, 1990). Therefore many Computer Aided Detection (CAD) techniques have been proposed to increase the accuracy.

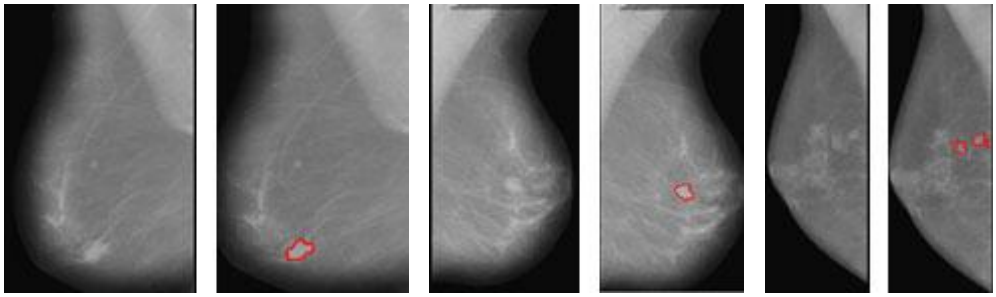
Mammographic mass detection system developed by our group, mainly consist with two parts: "Automatic breast boundary segmentation of mammograms" and "Mammographic mass detection using statistical techniques".

The first part is consisting with preprocessing steps of the mammogram. In mammogram image, lot of external artifacts such as identification labels, markers and wedges are present. Removing them and extracting only the breast area is important before seeking for the breast abnormalities. Following figure shows the mammograms with artifacts and preprocessed mammograms with Gaussian smoothing algorithm, Attribute morphological operators, modified fast marching algorithm and gradient information of the mammogram (Wirth et al., 2004; Yapa and Harada, 2007; Eli, 2009; The Mammographic Image Analysis, 2003).



Before After Before After

After extracting the breast region, program is looking for the masses in the mammogram. If any mass detected by the system will be highlighted on the mammogram. Contrast enhancing, Adaptive thresholding, feature extracting and artificial intelligence were used in the process (Singh *et al*., 2011; Bottema, 2000). Following figure shows the mammogram and detected masses (The Mammographic Image Analysis, 2003).



At present time there is no reliable way to prevent breast cancer. However, it is much more treatable when detected at an early stage, which is why regular mammograms are very important in early detection.

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PHARMACEUTICAL AND COSMETIC IMPORTANCE OF ASCORBIC ACID AND B-SITOSTEROL

D.M.D. Samantha Dissanayake
Board of Study in Chemical Sciences

Glycolipid is a specific organic material which consists of two parts: the sugar part is more soluble in polar solvents such as water and the other part is hydrophobic and prefers non-polar solvents such as organic solvents.

In this research we synthesized glycolipid having glucose as the polar part and β-sitosterol as the non-polar part of the glycolipid. Glucose is an abundant material in both plants and animals whereas, β-sitosterol is a cyclic alcohol found in green plants. β-sitosterol possesses several benefits for humans. It helps to minimize the prostate glands enlargements minimizing the potential of prostate cancer, stimulates the growth of hair and most importantly it reduces bad cholesterol level in the blood.

Liposomes and microemulsions were formulated incorporating the synthesized glycolipid where it functions as a building material for the liposome and as a co-surfactant for the microemulsion. Liposomes and microemulsions are known to show remarkable efficiency in the drug delivery in human body.

Liposome is a globular shape structure; it may have at least one membrane or more. They are thermodynamically stable; therefore water soluble drug can be encapsulated in the cavity of the liposome or among the membranes.

Vitamin C (ascorbic acid) was selected as the model drug for both liposome and microemulsion. Ascorbic acid is an important drug because it cures scurvy, functions as a cofactor in enzymatic reactions in human body and stimulates the generation of collagen fibers helping to keep juvenility. It also plays a vital role in healing wounds and preventing oozing blood from capillaries. In this project, liposomes are prepared by Reverse Phase Evaporation Method in order to achieve higher encapsulation efficiency. The encapsulation efficiency of 63% was achieved for ascorbic acid.

However, a major problem concerning vitamin C is its high sensitivity to alkaline conditions and heat. During the storage of ascorbic acid it undergoes decomposition with time. Our Liposome and Microemulsion accomplish better answer for this problem wherein the encapsulation helps to keep the ascorbic acid in its stable active form for a longer period of time. The applications of the research are in the preservation of the activity of ascorbic acid in formulations such as cosmetic skin creams and also in fruit juice preparations. Liposomes and microemulsions can improve the delivery of the ascorbic acid through the skin over cream formulations in which ascorbic acid is in the free form.

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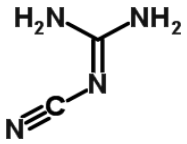
A LESSON FROM DCD ADULTERATED POWDERED MILK - WHAT WE OUGHT TO DO TOMORROW?

S. Malavipathirana
Board of study in Chemical Science

The issue of presence of Dicyandiamide (DCD) in imported powdered milk in Sri Lanka yet remains obscure in the minds of general public. News published in the media with different angles about this subject has led to the inconclusive understanding of the presence of DCD in imported milk.

What is DCD?

DCD is a simple synthetic chemical compound consisted of elements of carbon, nitrogen and hydrogen.



Chemical structure of Dicyandiamide (DCD)

DCD is a precursor of melamine (this is the chemical found in powdered milk a few years back which caused a tragic situation in China), and its uses are diverse. The crux of DCD related to this discussion is its use in pastures of countries having a giant dairy industry (for instance New Zealand), where thousands of cattles (specially cows) are fed. The basis of such use is to manage possible environmental pollution risk of cattle farming. In addition to that, the structure of the DCD exhibits its potential to be used as a nitrogen fertilizer which is an essential element in pasture (plant) growth.

Formation of Pollutants

Cattles grazing on such pastures/meadows excrete urine in large volumes. The inherent odour of urine is basically due to ammonia emits as a gas. The nitrogen in ammonia can combine with oxygen in soil, producing different oxidized chemical compounds. The process is facilitated by soil microorganisms. Nitrate, a known major nutrient is one of such oxidation products. Nitrate is infinitely soluble in water, and hence it is mobilized completely with water (aqueous phase). Thus, wastewater rich in inorganic nutrients such as nitrate is cumbersome to treat. A convenient and practical method of treatment of nitrate rich waters is not well established yet.

Transformation of cattle's urine into nitrate and subsequent leaching into surface and ground water sources has posed a severe pollution risk in these countries. Other major oxidized products are gaseous compounds, namely nitric oxide and nitrous oxide. Nitrate is a direct culprit of water pollution when in excess. The latter two gases are atmospheric pollutants.

Role of DCD

Excess nitrate in drinking water may cause disastrous repercussion on health. Therefore, the World Health Organization (WHO) has stipulated a maximum tolerance value of 50 mg per liter (ppm) for drinking purposes. DCD acts in pastures to manage the transformation ammonia in cattle urine into above mentioned pollutants. Therefore, the probability of entering DCD into cattle as a result of pasture application is apparent. It will undergo various enzymatic pathways to metabolize and could excrete via feces (cow dung) and urine. Any residues of such a substance can enter into other organs of cattle and very firstly in cow milk. Therefore undoubtedly it will be expressed in powdered milk.

Nevertheless, it is questionable whether such trace levels of DCD gets into cow milk via food chain, is high enough to be detected even with a sophisticated instrument. Consequently, if DCD is found in a reasonable level, it is highly likely that there may be other sources for DCD to be present in powdered milk. So in this context, intentional addition of DCD into powdered milk to increase the

protein content could be postulated. Amino acids are the basic units of protein. Presence of one unit of nitrogen is a common feature in any amino acid. Consequently, amount of total nitrogen in milk, coming from different amino acids in protein is a measure of its total protein content. Unfortunately, the common method used to ascertain nitrogen content in milk cannot distinguish the protein based nitrogen and the other non-protein nitrogen. As a result, presence of non-protein nitrogenous substances that can practically be miscible with milk may result in false positive protein content.

The structure of DCD (see the figure) demonstrates that one unit consists of four units of nitrogen. Thus, a unit of DCD can donate four units of nitrogen demonstrating that it is a good source of nitrogen. Consequently, one DCD unit can act as four units of amino acids, thereby, demonstrating the easy ability to be used to enhance the pseudo protein content in milk. The truth behind the adulteration of powdered milk with Melamine that caused irreparable damage to humans and animals especially in China a few years back is a similar scenario. Even though quantitative determination of DCD used in pastures is a questionable matter, if powdered milk is adulterated with DCD to enhance protein content, the levels of DCD can precisely be estimated quantitatively.

Impact of DCD

The toxicity of DCD is still unclear. The possible reason for the lack of comprehensive information on the toxicity of DCD would be due to non-existence of direct ingestion path ways. Presence of DCD in foods (eg. milk powder) drew attention very recently. Now the time has come to establish safe limits of DCD. Nevertheless, it is unavoidable the time required to set up a maximum residue level (MRL) of DCD. In such crux of matter, the best choice, as consumers would be to make sure that there is no DCD in any consumer product. If the consumer is in doubt whether the products purchased have been tainted with DCD or any other chemical(s), he/she should be wise enough to reject such products under any circumstances.

Our Responsibility

Before concluding the article, it is worth to mention that our lives are being trapped in complex customs and systems over the years. None can assure the safety of the food we consume at any strength of scientific knowledge. Through the diverse approaches, our lives are invaded by intentionally and unintentionally adulterated food. The bitter truth we experience through alarming growth of non-communicable diseases (NCD) such as cancers, heart attacks, kidney diseases with known and unknown etiology, sub fertility are some of the evidences of ourselves. There are no life savers other than us. The strength we have and the right we possess (customer right) need to be recognized individually and be acted on it collectively. It is important to draw the consumers' suspicious attention to any food prior to purchase. The consumer has the total right to reject if it is unsuitable for consumption. The DCD issue could be the most recent opportunity given us to open the eyes for a customer centered culture.

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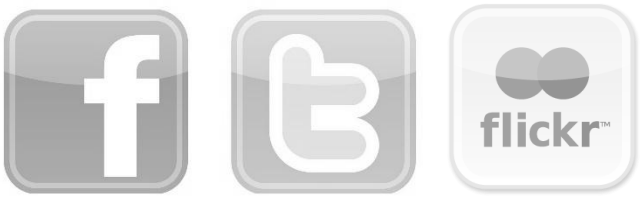
WHY WE NEED "CITIZEN SCIENCE" IN SRI LANKA

Piyal Karunarathne
Board of Study in Plant Sciences

It's an era of novel approaches into biodiversity conservation is in high demand and the conservation biologists have to be more innovative to make their efforts reach a greater distance and to be successful in the current age of rapid technological development at the expense of natural resources. Scientists believe that it's only through the involvement of general public, can the nature be conserved in a non-traditional and more efficient approach where interactive conservation benefits both the nature and the society (Schultz, 2000; Miller, 2005; David Bickford *et al.,* 2012). This is commonly known as Citizen Science. Europe and North America have been using Citizen Science as an effective tool of data collection at small and mega scale and they have achieved a huge success regionally which otherwise would have been extremely unlikely (Grove, 2012). Although, these techniques have been started in the tropical region recently, it has not prevailed as much and still in a dormant stage (Wee and Subaraj, 2009; Dickinson *et al*., 2012). Sri Lanka is far behind in the use of public involvement in scientific studies and it is the appropriate time to start a new journey of scientific studies in the country.

Crowd sourcing in scientific studies, commonly known as "Citizen Science" has been long used to collect data, nation-wide in several countries (Dickinson *et al*., 2012) though it has had a new leap with the technological development and easy access of modern communication protocols (Grove 2012). The term Citizen Science was first used by Alan Irwin in 1995. Although he used the term to introduce a type of research collaboration or data gathering technique by untrained or "non-expert" individuals, basically referring to general public, recently this field has gained a new direction allowing people to actively participate in scientific research (Mueller *et al*., 2012). Thus, current Citizen Science projects can range from large data collections like *Migratory Bird Surveys* (http://birds.audubon.org/christmas-bird-count/) and *What's Invasive* to more personalized small projects such as the programs offered by *Earthwatch Institute* (http://earthwatch.org). Despite the availability of experts, large scale monitoring or studies covering a large geographic area become limited due to the constrains of access to all the area at a given time; this is where citizen science plays the most vital role, especially in ecological studies. Rediscovery of a rare ladybird (*Coccinella novemnotata*) in North America and huge collection of bird citing data in Europe available on eBird (http://ebird.org) are such example of incomparable outcomes of citizen science projects. Currently this field has been revolutionized by the readily available novel technological equipment such as built-in GPS technology, web capable handheld devices such as mobile phones and cameras which are widely available and noticeably affordable. Moreover, Web 2.0 and social networks such as Facebook,

Twitter, and Flicker have enabled the researchers to collect a large amount of data even without making contact with the data collectors. For example, Catlin-Groves (2012) performed an initial survey of geo-tagged images of "monarch butterfly" on Flicker and her observations were similar to the results presented by citizen science program called Journey North (http://learner.org/jnorth/).



Sri Lanka with its rich biodiversity is part of the Western Ghats/Sri Lanka biodiversity hotspot (Myers *et al*. 2000) which is also among the top 18 biodiversity hotspots of the world. Together with unique plant and animal assemblages, the island harbors one of the highest endemism per unite area in the region (Mattson *et al*. 2004). However, recent studies suggest that immediate actions are needed to protect this precious complex of ecosystems as they are currently under the threat of being destroyed, jeopardizing the unique biodiversity (Gunawardena *et al*. 2007). People of Sri Lanka have an ancient history of living hand in hand with the nature and protecting it for future generations and for sustainability. However, current agenda of scientific studies in the country has not found a way to reach the people in an interactive conservation platform. Beside several community based studies, there has hardly been any citizen science projects in Sri Lanka.

Although Sri Lanka is a developing country, it is a potential ecological reserve for a variety of Citizen Science projects. There is a tremendous amount of natural phenomena occurring in the country which are yet to be studied (Baldwin 1991; Gunatilleke *et al*. 2006). Not only is the lack of studies affecting the deterioration of the biodiversity in the country but also peoples' concern about the nature is also deteriorating day by day. Crowd sourcing can be efficiently used to address a lot of environmental issues in the country as well as a large amount of social matters. Hence, it can range from getting school children to collect data for small scale local studies to getting rural communities to help monitor deforestation and illegal poaching. In this way Citizen Science can improve the livelihood of the people and interaction of youth with the nature while taking the scientific studies in the country to a new level. Further, when it comes to large scale monitoring of ecological conditions such as distribution mapping of certain species or group of organisms, it is always good to have a large workforce in which non-experts play a major role as it becomes impractical for researchers themselves to collect a vast amount of data covering the entire country. Current technological exposure of the country will possibly reinforce the scientists' efforts by providing easy means of accessibility to data collectors. As for now, there are more than 10 million mobile phone users in Sri Lanka and two third of them are web enabled devices (World Bank, 2012). When properly strategized, they can be easily used to collect scientific data. Social network community in Sri Lanka is steadily increasing; for example there are over 1.2 million facebook users in the country (Wordpress 2012). Several facebook groups such as "Sri Lanka Birding Circle" (https://www.facebook.com/groups/135397896538713/) and "Butterfly Interest Group of Sri Lanka" (https://www.facebook.com/groups/153339521374784/) have already been filled with potential Citizen Science data, although no one seems to use the data to conduct surveys or other scientific studies. These tools would obviously provide very important sources for Citizen Science projects in the country.

However, there are certain reluctances among the researchers to use data collected by non-experts for scientific studies as there is no assurance of the reliability of these data. It should start from Sri Lankan researchers themselves to improve the quality of data collected by people and to use the right methods to collect reliable data avoiding fallacies. Moreover, convincing people to participate in scientific research would be another concern for starting citizen science projects in the country. To overcome this hurdle, the electronic and printed media should play an important role linking researchers with the general public. Finally it's up to the scientists to use this invaluable and important tool properly to transfigure the research culture in the country.

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HUMAN-ELEPHANT CONFLICT AND SOLUTIONS TO IT IN SRI LANKA.

M.P.J. Dharmaratne[1,2] and P.C. Magedaragamage[2]
[1]*Board of study in Chemical Sciences*
[2]*Ceylon Wild life Agency (CWA)*

One of the major instigators of human–wildlife conflict is competition for space. Destruction of forests through logging, encroachment, slash-and-burn, shifting cultivation, and monoculture tree plantations are major threats to the survival of elephants. Human–elephant conflicts occur when elephants raid crops of shifting cultivators in fields, which are scattered over a large area interspersed with forests. Depredation in human settlements is another major area of human–elephant conflict occurring in small forest pockets, encroachments into elephant habitat, and on elephant migration routes. Between 1999 to the end of 2006 every year nearly 100 wild elephants were killed. Elephants are being killed by farmers to protect their crops and houses. (DWC, 1999 - 2006). Cost of human-wildlife conflicts is of three types: direct, indirect and opportunity costs. (Thirgood, Woodroffe & Rabinowitz, 2005)

Direct Cost

Crop Damage

Crop damage is perhaps the most prevalent form of conflict across the Asian and African continents. When elephants damage food and cash crops, they affect a rural farmer's livelihoods. Elephants in large groups can destroy large areas of crops in a single night. While elephants target staple food crops such as rice and maize, furthermore they were attacked to the cash crops such as sugarcane and coconuts. Santiapillai *et al.,* (2010) calculated that an average farmer in elephant affected areas of Sri Lanka losses over USD 200 annually for crop damage, while in Thailand, farmer cost of the conflict accounted for 25% of their annual income (Jarungrattanapong & Sajjand, 2011). The tragedy indirectly repercussions for health, nutrition, education and ultimately, development (Ekanayake *et al*., 2011; Fernando *et al*., 2011)

Human Death and Injury

Elephants kill and injure people across the Asian and African continents. Most of those killed are men, and many of these incidents occur during the night. The research carried out in India, Sri Lanka and Kenya shows alcohol was found to be a key factor in one third of the deaths; victims were drunk and returning home from the bar (Parker *et al*., 2007) Others died protecting their crops, herding cattle and walking at night between neighbouring villages.

Indirect Cost

Farmers' lost time for protecting crops and property and compromised family security account for indirect costs. While indirect conflicts do not directly impact livelihoods, they still have a negative effect upon people's lives. For example, the fear of running into elephants may restrict people's movements between villages, especially where attacks have recently occurred. Such fear among

children may reduce school attendance, or interfere with the collection of fuel wood and thatch grass, or the collection of wild fruits or other resources (e.g.: Wood apple, Wild mango).

In the crop raiding season farmers and their families will be required to guard their crops and property, leading to loss of sleep and energy, poor employment opportunities, increased exposure to infectious diseases and psychological stress (Parker *et al.*, 2007). Such indirect costs do not translate well to economic value and so are difficult to compare conventionally.

Opportunity cost

Opportunity cost of different conflict management approaches can be calculated by the forgone income for farmer household commitment to fight the conflict (Thirgood, Woodroffe & Rabinowitz, 2005) and can be presented as a percentage loss of annual income.

Solutions

Government and non-governmental organisations have taken considerable effort in reducing Human elephant conflict. Some of these are:

Governmental organisations:

The most expensive but effective way of controlling elephant raids using electric fencing but the cost of design and materials used for electric fencing is quite high and Fernando et al. (2008) estimates it as USD 3,500-5,000/km in Sri Lanka.

The elephant conservation strategy of the Department of Wildlife Conservation (DWC) aims at conserving as many viable populations as possible in as wide a range of suitable habitats as is feasible. This means protecting elephants both within the system of protected areas and as many animals outside these areas that the land can support and landholders will accept, and not restricting elephants to the protected area network alone.

Non-governmental organisations: Ceylon Wildlife Agency's (CWA) aim is to provide effective solution to minimize human elephant conflict identified. Three approaches to address this issue are:

Short-term approach: Organise and mobilise farmers in conflict villages and raising deep awareness on elephant behaviour patterns.

Midterm approach: Erection of Dandu Weta (Log fence) along the areas where elephants cross. Villagers in some of the frequently raided areas have experienced that the invasion could be prevented with the Dandu Weta or the Wooden Fence. The fence is erected using large logs and does not fix strongly on the ground. When touched it moves as it is not steadily fixed. Usually elephants do not touch or move over fences those are swinging or unsteady (De silva and De Silva, 2007)

Long term approach: Habitat enrichment. This could be done by planting fodder trees in the elephants' forest areas. For example, cultivating Beru (a water grass elephants love to eat) in tanks (reservoirs) and other trees (such as Velang) that form main part of the diet of elephants. There are about 100 species of plants that are eaten by elephants.

The best and the long-run HEC mitigation approach is conservation policy planning precise for different geographical locations. This needs years of research, awareness and lobbying and more importantly, political willingness.

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COMPOSITE-TYPE FIBERSCOPE SUPERSEDES ENDOSCOPE

P.M.P.C. Gunathilake
Board of Study in Statistics and Computer Science

The Composite-type Optical Fiberscope (COF) integrates light illumination transmission, image transmission and irradiation laser transmission into a same axis (Oka K., 2006). The diameter of a COF is about 0.8 mm. It has about 6,000 image transmission fibers and a laser irradiation fiber as shown in the Figure 04. The optical fibers for image transmission are surrounded a single optical fiber for irradiation laser transmission, those two types are the functional laser fibers in the COF.

The physical properties of COF have direct impact with its applications. Thinner insertion tubes can be inserted into the narrow sections without any extra force as shows in Figure 06. Smaller head and the flexibility of insertion tube may increase patient comfort as well. With respect to the COFs applications the irradiation ability is one of the most important features (Oka K., 2008).

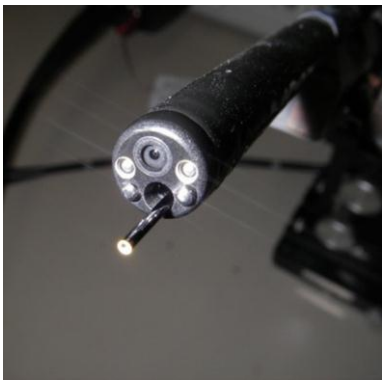

Figure 01: Tip of Conventional Endoscope, usually the diameter is 4 mm to 6 mm

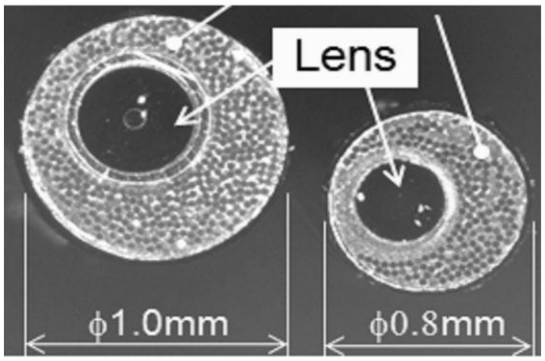

Figure 02: Tip of Composite-type of Fiberscope, usually the diameter is 0.8 mm to 1 mm

Difficulties of Conventional Endoscope

1. Two devices are required.
2. Application to a narrow part is difficult.
3. Precise positioning is difficult.
4. Due to the laser irradiation range is indefinite, unevenness occurs

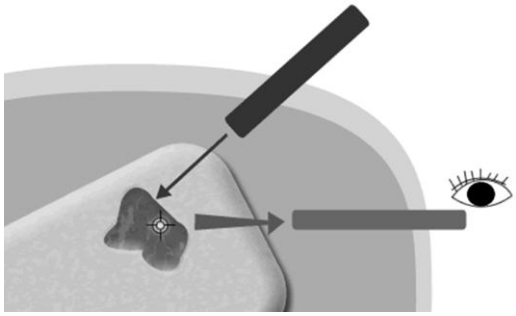

Figure 03: Positioning of Endoscope

Solution with COF

- Fibers for laser transmission and image transmission are integrated into the same axis. (Figure 04)
- Separation and integration of laser beam (1064 nm) and image(400~780 nm).
- Easy insertion to a narrow parts. (Figure 05 and Figure 06)

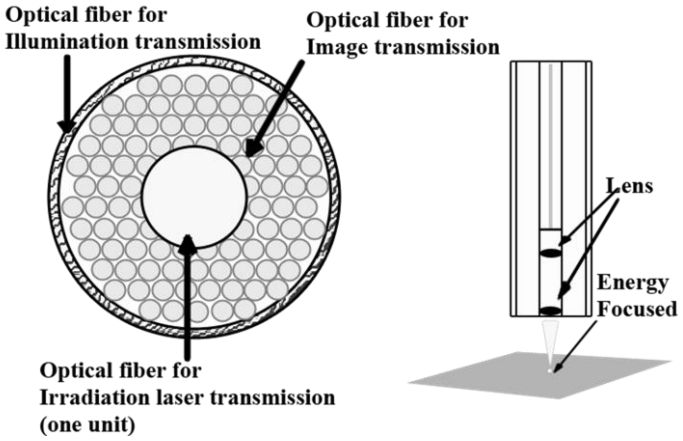

Figure-4, Arrangement of laser fibers

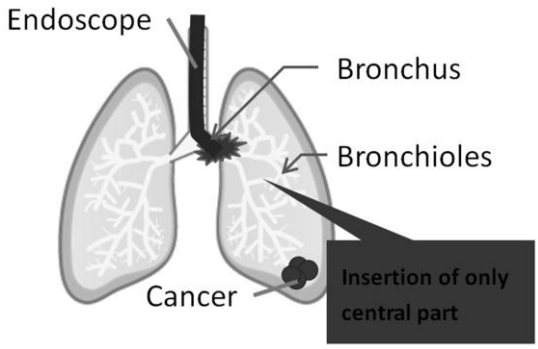

Figure 05: Issues of the conventional Endoscope

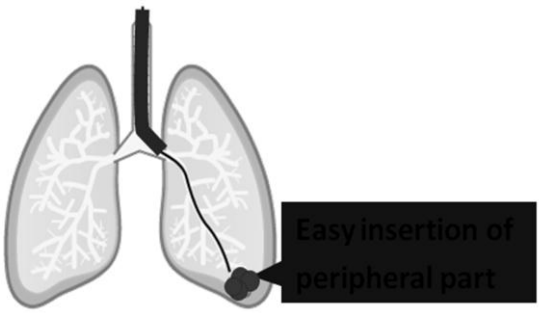

Figure 06: COF: Easy insertion, no expansion

References:

Oka, K., Naganawa A., Yamashita, H., Nakamura, T. and Chiba, T. (2008). Composite-type Optical Fiberscope for Laser Surgery for Twin-to-twin Transfusion Syndrome. Medical Imaging and Augmented Reality (Springer Berlin/Heidelberg, *Lecture Notes in Computer Science*), 5128:251-9.

Oka, K., Nakamura, T., Harada, K., Ohkawa, Y., Hidaka, T. And Chiba T. (2006). Development of laser forceps for fetal surgical treatment. *World congress on Medical Physics and Biomedical Engineering,* 2976-9.

APPLICATIONS OF TRANSPARENT CONDUCTORS

Sampath Ranasinghe
Board of Study in Chemical Sciences

The term of transparent conductors (TC) is not very familiar to many people although they have dominated human lives in every aspect. Most of the present day electronics devices and various other applications featured with these materials to deliver unimaginable things several decades ago. Touch-screen sensors, low emissivity windows, liquid crystal display (LCD) devices, plasma and organic light emitting diode (OLED) displays, smart windows, and photovoltaic devices are just a few of innumerable technological applications possible for these materials.

Most of these TCs are metal oxides. Thereby they are also known as the transparent conductive oxides or TCOs. It was first discovered by Badeker and he reported the electrical conductivity of the material formed by the oxidation of Cd metal deposited on the inner walls of a glow discharge tube in 1907. The property of these materials should deliver high electrical conductivity as well as transparency to visible light. The light absorption property of a material is directly related with the band gap of the material. Therefore to be considered as a TCO, it should possess a band gap of $E_g > 3.0$ eV, where they are also called wide band gap semiconductors. The transparency and conductivity are two main properties and which are interrelated features for most of the TCOs when it is doped to achieve high conductivity than its intrinsic TCO. Generally, the TCOs are expected to have more than 85% transparency and conductivity of 10^6 S m^{-1}. Since the first reported TCO, numerous oxides such as Sb- doped SnO_2, F-doped SnO_2, Sn-doped In_2O_3, Cd_2SnO_4, $CdSnO_3$, $CdIn_2O_4$, Al-doped ZnO, Ga-doped ZnO, F-doped ZnO materials have been exploited. These TCOs have different properties like thermal stability and chemical stability, other than their two main properties. For example, the F-doped SnO_2 shows best chemical stability while ZnO based oxides show lowest in chemical stability where their conducting properties show the opposite. Therefore, selectivity of the TCO depends on the final application.

Thin films of these materials are commonly deposited on optically-transparent substrates such as glass. It is important to know some of the fabrication techniques available to fabricate these semiconductor thin films on these substrates. TCO layers can be deposited using many techniques such as chemical vapor deposition (CVD), electron beam evaporation, pulsed laser deposition, RF magnetron sputtering, atomic layer epitaxy, spray pyrolysis and sol-gel processes. Among these techniques, spray pyrolysis is a simple technique which can be used to prepare large-area films with uniform morphology. To obtain high quality TCOs, our research group at University of Peradeniya has also developed a novel spray pyrolysis technique, which is known as Atomized Spray Pyrolysis (ASP) for fabrication of F-doped SnO_2 thin films. Following applications are not possible without these TCOs. Most of these applications use the TCO deposited glass substrates as the main electrode of the relevant device.

1. Touch-Screen Sensors. - Touch screens have now become a part of the human lives which expanded it uses from simple cell phone to sophisticated mechanical instruments. The structure of the device is quite simple as shown in figure 01. The device is constructed using TCO deposited on glass substrate and transparent patterns are made on it using various lithographic techniques. Screen pattern is fed in to a software, where the detection of change in resistivity at where it is touched can be identified through the microprocessors. This is the simplest and earliest device architecture, where all the materials used are transparent, so when it incorporated with any display device user can see through it without any disturbances.

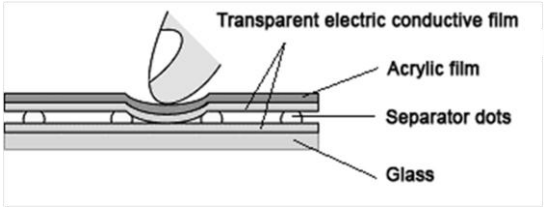

Figure 01. Device architecture of touch screen sensor. (DMC Co., Ltd. 2004)

2. Low Emissivity Windows and Smart Windows. - Smart windows are one step beyond the concept of low emissivity windows. The low emissivity windows are used to block a particular range of wavelengths incident from outside of the window. For instance, most of the low emissivity

windows are used to prevent IR radiation transmittance through the window. This helps to reduce the heat inside the building without a reduction of incoming light. Most of the smart windows are also capable of deliver this feature with additional colour controlling property which means a control of incoming light. The TCO is coated with photochromic or electrochromic materials where colour depends on the application. When the window is coated with electrochromic materials and incorporates with electronic control system the window colours and pattern can be varied in seconds giving new dimension to decoration of modern buildings.

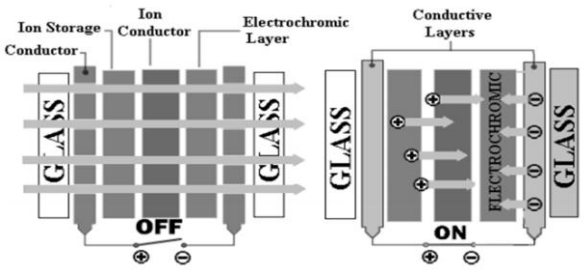

Figure 02. Device architecture of an electrochromic window. (Guangxi 2010)

3. Display devices. - There are several displays devices have been developed using TCO electrodes. Among these, Liquid Crystal Display (LCD) is one of the most common. The device is constructed on a TCO which has patterns constructed using lithographic techniques and liquid crystals have placed in between two TCOs. The crystals orient as the electrical signals received through the two TCO electrodes and colour is generated. Several other transparent layers also include in the device to optimize the display features to the user.

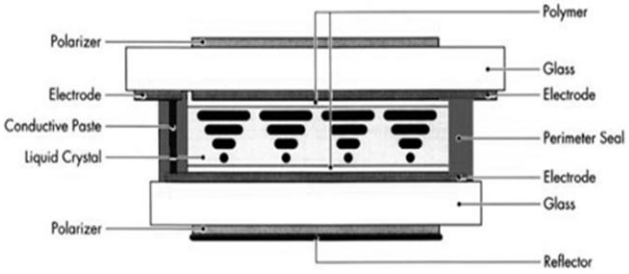

Figure 03. Device architecture of LCE display. (Blaze Display Technology Co., Ltd. 2014)

4. **Photovoltaic devices. –** Photovoltic devices are the devices which can generate electrical power in the presence of light which are commonly known as solar cells. Most of the available solar cells are constructed on TCO coated glass substrates. The Dye-Sensitized solar cells, tandem cells, and organic solar cells are well known among the researchers. Organic or inorganic semiconductors are deposited on the TCO to create p-n multi-junction or heterojunction according to their band gaps and band. These devices are most promising candidate to replace the conventional silicon solar cells which can deliver high efficiencies in harvesting solar energy.

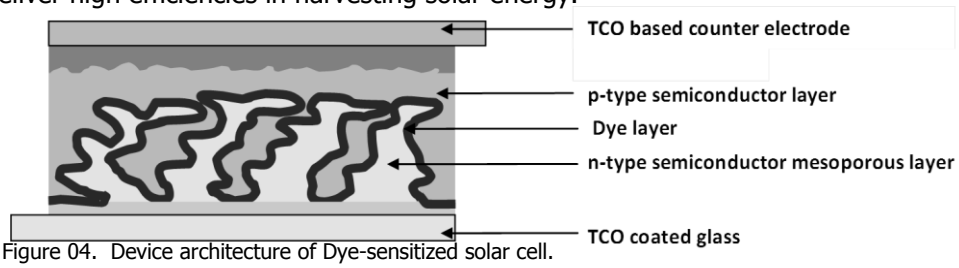

Figure 04. Device architecture of Dye-sensitized solar cell.

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